SCIENCE TEACHER'S WORLD

Teacher's edition of Science World • November 11, 1958

Toward more effective lab work in science

In the 1920's and 1930's, there was a flurry of debate in the science-teaching fraternity over the relative merits of individual student laboratory work and teacher demonstrations. Each side in this laboratory-vs.-demonstration controversy fortified its arguments with "research" findings purporting to show that one method or the other was superior in terms of better recall, longer retention, more adequate understanding as revealed by application, and the like. The fact is that to this day *both* methods are being used in science teaching, each making its unique contributions to the science learning of students. That there was ever an issue in the first place stems from the lack of a clear common understanding of what we mean by "laboratory work" in secondary school science. One purpose of this article is to propose an understanding of this term on which we might all agree. Another purpose is to suggest teaching procedures that might permit laboratory work to make its unique contribution in science education.

Types of laboratory work (in order of complexity)

If you were to tour the country and observe laboratory work in American high schools, you would see science classes engaged in a considerable variety of activities. These activities might be classified along the following lines:

1. *Observing objects.* In a biology class, students might be seen peeling skin from the leaves of an onion, placing the skin on a microscope slide, adding a drop of Lugol's solution and a coverslip, and then observing the skin under the microscope. In a chemistry class, students may be observing various types of crystals. Physics students might be observing types of magnets used in various devices — bells, telephones, phonograph speakers, electric meters.

2. *Observing phenomena.* You might see a biology teacher giving groups of students a twelve-inch length of glass tubing closed with Scotch Tape at either end and containing a half dozen or so fruit flies. The students are told to hold the tube with one end toward the window and observe what the flies do; then, to reverse the tube and observe what the flies do. Physics students may be seen sprinkling iron filings on a cardboard over a horseshoe magnet to observe the magnetic field. Students in a chemistry class may be seen adding acid, then base, drop by drop, to an indicator solution to observe changes in the color of the indicator solution.

3. *Practicing a method.* In preparing oxygen in the laboratory, chemistry students may be learning how to connect tubing, how to heat substances safely in a test tube, and how to collect gases by displacement of a liquid. In a chemistry class carrying on a titration, students may be learning how to control the drops of reagent, how to read the meniscus, and how to determine the end-point. In work on refraction in a physics class, students may be learning how to trace a ray of light by the use of pins. A biology class may be learning how to use the microscope or how to make a good blood-smear.

4. *Answering a question.* "What foods are starchy?" may be the question undertaken by a biology class that has mastered the method of detecting starch. Students would bring into the laboratory all kinds of foods and test them. A chemistry class may be finding out which contains more vitamin C — an orange

YOUNG SCIENTISTS

Teachers are urged to have their students submit write-ups of interesting projects or experiments they have done. If printed in SCIENCE WORLD, full credit will be given to the student, the school, and the teacher. In addition, the student will receive $15. Contributions should be addressed to Science Project Editor, Science World, 575 Madison Avenue, New York 22, N.Y. Students should be reminded that by submitting their ideas they can do a service to thousands of other students.

or a vitamin pill. In a good teaching program, they would first have to learn how to perform a quantitative test for the vitamin. (That would fall under classification 3, above.) A physics class may be devoting laboratory time to finding out which of a number of given substances is a good conductor of electricity.

5. *Testing a hypothesis.* This category is closely related to category 4, yet it is significantly different. To be sure, here also a question is being answered, but it is broken up into a cluster of questions. To illustrate: What determines the strength of an electromagnet? Is it the size of the core, the composition of the core, the thickness of the wire, the number of turns of the wire, the strength of the current? Each question lends itself to the design of an experiment for finding the answer. This type of laboratory work, when properly introduced, offers the student an opportunity to be an embryo scientist at work. Yet this is the kind of laboratory work most seldom encountered in our high schools.

It will be observed that the above categories of laboratory work are not mutually exclusive. Answering a question in the laboratory requires methods and techniques which, in turn, certainly involve observation of phenomena and objects. But these categories are related in the same way that letters, words, and sentences are related. Writing a sentence involves writing words, and writing words involves writing letters. The letters have meaning only in terms of words, and the words have their greatest significance when they are parts of a meaningful sentence.

Criticism of present practices

What criticisms are being made of present teaching practices as related to student laboratory work in science? In biology, the laboratory work seldom goes beyond the observation stage. In chemistry, it is largely a pupil exercise in following cookbook directions. In physics, the work does not generally represent a motivated challenge to the pupil's intellect. In all the sciences, the laboratory work seldom involves the teamwork called for when groups of students attack different aspects of the same problem. (See "Testing a Hypothesis" above.)

Critics have often been altogether too severe — even unreasonable. After all, a great many understandings in biology do depend on observation; cookbook directions are unavoidable if students are to work safely and acquire necessary skills in chemistry laboratory techniques. But the critic is on firmer ground when he asserts that, while these types of activities are necessary, they do not go far enough. *Somewhere* in the course of study, *sometime* during the school year, *somehow* in the teacher's planning, a student studying a science should be placed in the situation of a real scientist. He should be confronted with a problem arising out of his experience, and he should be motivated to plan and carry out strategy to find possible answers. What can a teacher do to bring this about?

Pattern for 'scientific' lab work

How may a class be charged to do "scientific" laboratory work? In the first place, the work should grow out of direct, firsthand experience with a natural phenomenon. Usually, this comes in the form of one or more demonstration-lessons given by the teacher. The problem-question should be elicited from the class, should be in "operational" form, and should be clearly stated. This requires considerable teacher skill in directing discussion and in catalyzing clear thinking.

The class should participate in planning. The planning should go beyond general methods of attack on the problem; it should involve the minutest details of procedure, including "checks" and instructions for recording data. In this, the teacher must become an active working partner, giving the class benefit of his special competence and experience. This, too, requires special skill, for it is more effective if — instead of just telling his students — the teacher leads them to understand that a suggested procedure is unsafe, impractical, or ineffectual. The laboratory activity itself should involve students in the gathering of quantitative data. Finally, the laboratory period should be followed by student reports to the class and by class discussion of the data. "Checks" should be compared; discrepancies will generally be found. Hypotheses should be elicited to explain these discrepancies. Here, too, the experience of the teacher should come into play. Above all, the post-laboratory discussion should lead not merely to a "conclusion"; it should lead to challenging outcome-questions.

Can it be done?

If there is sufficient reader demand, we shall publish in future issues of SCIENCE TEACHER'S WORLD some specific examples of this kind of laboratory work. Each laboratory experience might consume as much as a week of teaching time; this includes approach, student-teacher planning, work, and follow-up discussion. The laboratory work itself may consume but a single laboratory period.

Teachers may be quick to protest that they cannot afford so much time. It is true that *every* laboratory lesson cannot be done in this way — this, of course, would be highly impractical, even if it is desirable. But certainly a teacher can manage to give his pupils at least one such experience each semester. This investment of time would be feasible and well worth while. — ZACHARIAH SUBARSKY

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MEMO

To: Science teachers

Subject: Ways to use this issue of SCIENCE WORLD in the classroom

Telltale trees

Skin-diving for tomorrow's oil

BIOLOGY TOPICS: practical applications of biology, ecology
EARTH SCIENCE TOPICS: location of mineral deposits; stratigraphy; vocational guidance

What possible reason might an oil company have for engaging skin-diving geologists to make a survey of the fauna of the ocean floor?

What possible purpose might a mining corporation have in sending men aloft in airplanes to observe such things as the density of poppies or the kinds of trees that grow in a given area? What reason might a prospector for minerals have to take plant cuttings to a laboratory for analysis?

These questions are answered in the two articles listed above. Each article presents for the student some rather unusual and unsuspected applications of biology. What is more, the articles present a host of unanswered questions currently being investigated. These questions suggest attractive areas of work for some future scientists now in high school.

John Dalton: First atomic scientist

CHEMISTRY TOPICS: introduction to chemistry (pioneers in chemistry); atoms and molecules; atomic structure (historical background)

Miss Wyler charmingly sketches the life of Dalton and describes the fundamental studies that have made him immortal in the history of science. The chemistry teacher might well use this article as more than historical background. He can use it to illustrate that the most important tool of the scientist is not apparatus but brains. What Dalton lacked in the way of experimental equipment was more than compensated for by his brilliant imagination. In fact, the whole of chemistry may be regarded as a product of human imagination, checked and double-checked against experience. The article might also be used by the teacher to show how fact gives rise to theory.

Another significant point might be emphasized through the article — namely, that communication is a basic ingredient of the scientific enterprise. This is brought out by the stimulation Dalton received from his membership in Manchester's Literary and Philosophical Society and by the clues that came to him from the work of Lavoisier and Proust.

Here is a suggestion on how to approach the article. Present to the class the data — and *only* the data — given in Miss Wyler's article as available to Dalton. Then challenge the class to come up with an explanation of this data. The explanation won't come readily, if it comes at all. Now ask class members to read the article. Their appreciation of Dalton's genius will be all the greater.

Florida's 'red-tide' mystery

BIOLOGY TOPICS: introduction to biology; nutritional relationships; ecology — conservation; economic importance of protozoa; evolution; vocational guidance; unsolved problems in biology; reproduction; behavior — tropisms

Roy Gallant's detailed and vivid description of this spectacular phenomenon and its historical associations can serve very well in an introductory unit in the biology course. The article deals with biologists at work in field and laboratory and provides an insight into the many ramifications of a problem, as one clue after another is pursued through research.

The article can also be used either as introductional or terminal material in a unit on protozoa, or just as enrichment material in such a unit.

The factors involved in the explosive multiplication of these protozoa and the catastrophic effects on marine life make a fascinating ecological story. This can be brought into the classroom

study of ecology and of evolution (overproduction, survival).

The article can also make a significant contribution to a biology class by broadening the horizon of students. It will reveal a wide range of biological vocations in microbiology, oceanography, and fish and wildlife conservation.

Here are some questions that can be used to motivate students to read the article:

1. How did the Red Sea get its name?
2. How is it possible for protozoa in the ocean to cause a dog to sneeze?
3. How can protozoa kill a fish without entering its body?
4. How can rain on *land* cause protozoa to increase in the *ocean*?

Behind the scenes with Isaac Newton

PHYSICS TOPICS: inertia; momentum; reaction
BIOLOGY AND GENERAL SCIENCE TOPICS: survival in space travel

This picture feature might be used by the physics teacher either as an introduction or as "applications" in teaching Newton's laws of motion. From these scenes, the class can then be led to consider everyday situations in which Newton's laws apply. For example:

Here are some rules of good and safe driving. Which of Newton's laws is involved in each rule? Explain how.

1. Slow down when approaching a curve in the road.
2. Keep at a safe distance behind the car in front of you.
3. To save gas, drive neither too slow nor too fast.
4. If your car is equipped with safety belts, use them.
5. When you use your car to push a disabled car, start up very slowly.

Two questions for class discussion: Which of Newton's laws are you applying when you bounce a basketball? When you use a rotating lawn sprinkler?

In general science and biology classes that are studying space travel, the pictures can be used as an approach to problems of survival. For example:

Which of Newton's laws would have to be taken into consideration in answering each of these questions about space travel?

1. What should be the position of a man in a rocket ship during take-off?
2. How can a rocket ship be steered after it leaves the earth's atmosphere?
3. How might a man be put into "artificial gravity" to overcome weightlessness?

Case of the silent howlers

BIOLOGY TOPICS: yellow fever; conquest of disease (other topics listed below)

The science teacher can inspire students by providing situations — real or vicarious — in which students can feel the mystery of the unknown and later experience the joy and satisfaction of discovery. One such "situation" is provided by the article that begins in this issue. Indeed, the article contains a whole *series* of mysteries and discoveries. They all bear on a set of diseases that go under the name of yellow fever.

The story greatly extends the meager and fragmentary information that most high school biology textbooks carry about this disease and its conquest. Furthermore, the story nicely illustrates the way in which laboratory and field studies may supplement each other in the solution of a biological problem. And it shows how the solution of a problem often comes through the interplay of many minds. The problem involved scientists from a host of scientific, governmental, and even international agencies — the United States Army Medical Corps, the Pan-American Sanitary Bureau, The Rockefeller Foundation, the Carlos Finlay Institute in Bogotá, the Gorgas Memorial Laboratory, and the World Health Organization of the United Nations. Thus, the story presents for the biology teacher an opportunity to impress upon his students the social significance of science.

Here are some topics in the biology syllabus to which this and future installments of Murray Morgan's story may be related:

UNIT: INTRODUCTION TO BIOLOGY
TOPICS: biologists in field and laboratory; the practical importance of biology in human affairs

UNIT: HEALTH AND DISEASE
TOPICS: yellow fever — a set of virus diseases; how some types of yellow fever are transmitted; how the mystery of jungle yellow fever was solved; how epidemics are studied; how health agencies co-operate in the conquest of an infectious disease.

UNIT: REPRODUCTION
TOPIC: how some mosquitoes insure the survival of their eggs during dry seasons

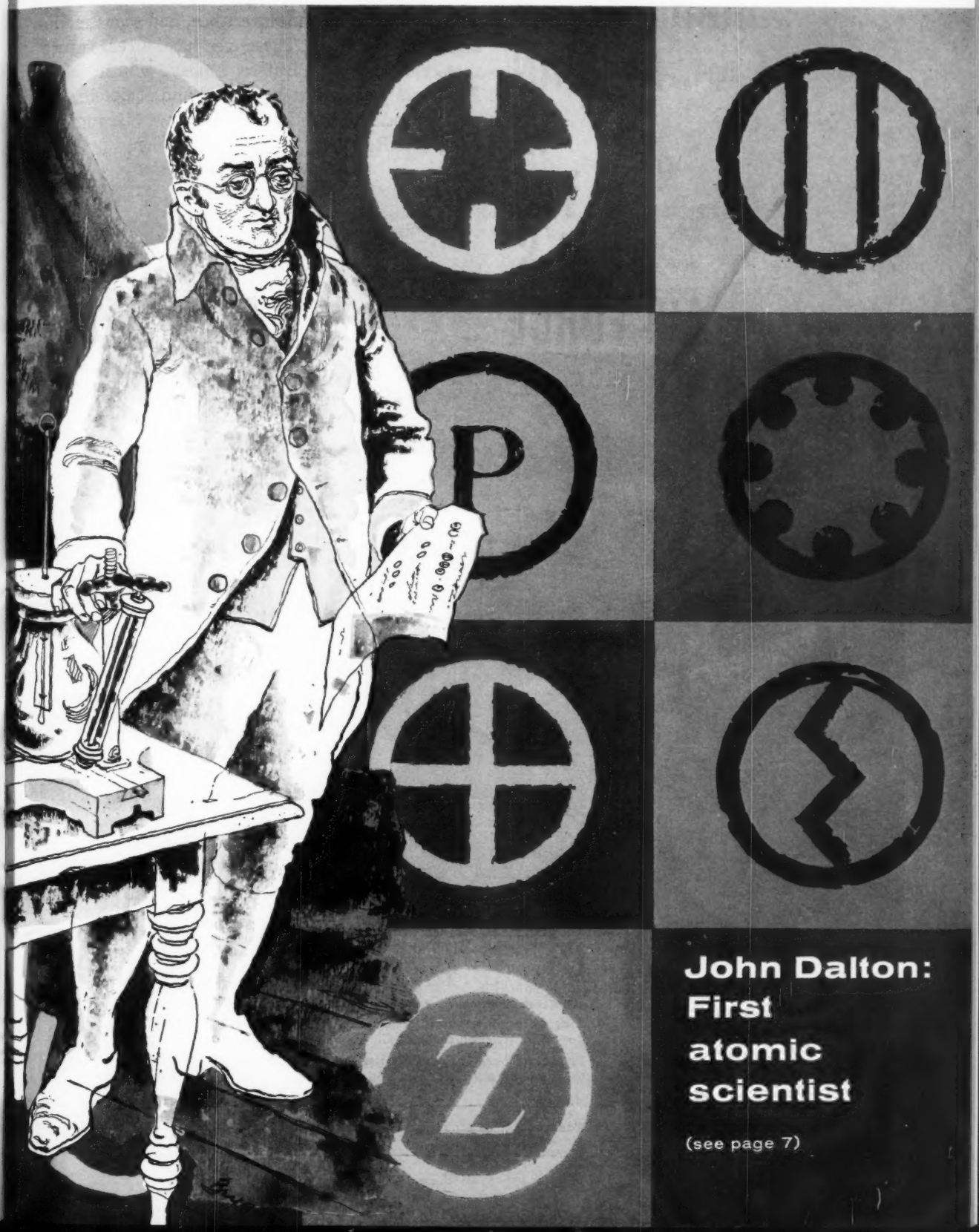
UNIT: BEHAVIOR
TOPIC: the strange behavior of the *sabethes* mosquito

UNIT: ECOLOGY
TOPIC: the vertical distribution of some tropical mosquitoes

NOVEMBER 11, 1958

SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS



John Dalton: First atomic scientist

(see page 7)

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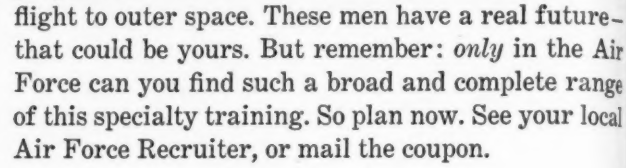

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SCIENCE WORLD

THE SCIENCE MAGAZINE FOR HIGH SCHOOL STUDENTS

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Coming in SW November 25

What significance has ballooning in the Space Age?

Is it possible to harness tidal power for electricity?

Leonardo da Vinci studied this animal for his flying machine, and today's sonar experts are also studying it. What animal is this?

For answers, see the next issue of *SW*. Meanwhile—drive safely.

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About the contributors

HYMAN RUCHLIS is director of the Science Materials Center, a new division of the Library of Science. His current projects: classroom kits for experiments on magnetism, static electricity: toys involving scientific principles. Mr. Ruchlis was formerly chairman of the science department at Bushwick High School in Brooklyn, New York.

Another former teacher, ROSE WYLER, continues to write about the men who make science history. Miss Wyler often collaborates with her writer-husband, Gerald Ames.

LYNN POOLE, who is director of public relations at Johns Hopkins University, produces the famous "File 7" telecasts. He is author of a number of science books.

SW's "Stranger Than Fiction" author, Murray Morgan, boasts an STF background, too — bridge-tender, newsman, college professor, radio broadcaster. Material for his book *Doctors to the World* was culled from his visits to 22 countries — a 28,000-mile trip.

SCIENCE WORLD is published biweekly during the school year, September through May inclusive (8 issues per semester, 16 issues per school year), except during school holidays and at mid-term by Street & Smith Publications, Inc., 575 Madison Avenue, New York 22, N.Y. Second-class postage paid at New York, N. Y., and at additional mailing offices. © 1958 by Street & Smith Publications, Inc., in the United States. Subscriptions, U.S.: $1.00 per semester (8 issues); two-semester subscription (16 issues), $1.50; single copy, 15¢. Back copies, 25¢. Canadian subscription rates are the same as United States; additional postage for countries in Pan American Union: one semester, $1.00, two semesters, $2.00; cost of additional postage for other foreign countries: one semester, $1.50, two semesters, $3.00. Address all subscription mail to Science World, 304 East 45 Street, New York 17, N.Y. Send notice of undelivered copies on form 3579 to: Science World, McCall Street, Dayton 1, Ohio.

Printed in U.S.A. 24

— Standard Oil Co. (N. J.)

NO FIREFIGHTER, this man is flushing snow from a New York street with a powerful stream of water. Notice how he braces his body, leaning forward. Why must he?

A PANIC-STRICKEN DEER plunges through a window to escape from a building into which it wandered. Despite the flying glass, the deer's eyes are open and its face and body seem unscratched. Though we don't know what happened to the deer, it may not have been injured at all. How could this happen?

— U. P. I.

Behind the scenes with Isaac Newton

What does a man-made satellite hurtling through space have in common with the kicking of a football? Or with a man walking or jumping? All are forms of motion. And all motion can be explained by the work of a man who lived more than two centuries ago. The man, of course, was Sir Isaac Newton. The photographs on this page show some ordinary and some not so ordinary happenings. Each can be explained by Newton's laws of motion. Try answering the questions. Then turn to the following page.

By Hy Ruchlis

The material for this article was drawn from the book **Orbit**, *written by Hy Ruchlis and published by Harper & Brothers. Copyright, 1958, by Hy Ruchlis.*

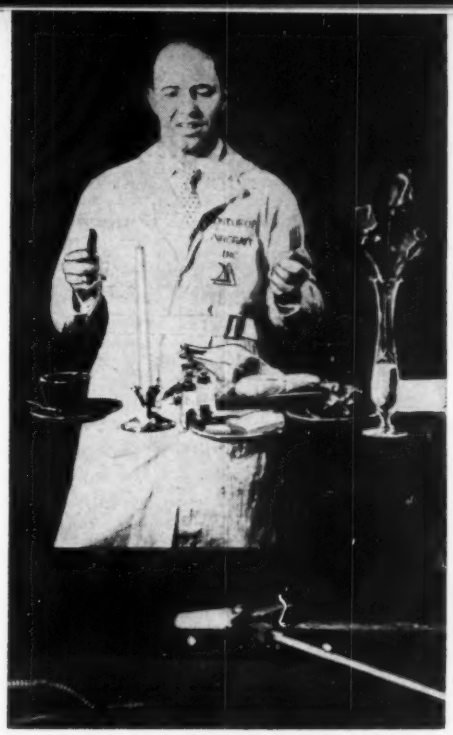
HITTING THE SILK, a parachutist jumps from a helicopter. Though he has fallen some distance, he is still below the open door of the helicopter, even though it is traveling at a fair speed. Why?

— Wide World

— U. P. I.

HIGH-SPEED X-RAY PHOTO shows what happens when a football is kicked. The foot penetrates deep into the ball. As a result of the penetration, the kicked ball develops more speed and goes farther. Why?

BRACING THEMSELVES, firemen prepare to net a man jumping from a building. Notice how high they hold the net. Can you explain why? Do you see any connection between this and the football photo?



— Northrop Aircraft, Inc.

TRICK PHOTOGRAPHY was not used here. The chicken dinner is actually suspended in mid-air — though it stayed there for just an instant before it fell. The dinner had been resting on a high-speed sled used to test airplane equipment. The sled (its edge can be seen at far right) was catapulted out from under the dinner, and a high-speed camera took the picture. Why was the dinner left behind when the sled shot forward? How is this situation similar to that shown in the parachutist picture?

— Ewing Galloway

Answers to 'Behind the Scenes with Isaac Newton'

Hose

Newton's third law of motion provides the clue by which you can answer this question. The powerful action of the water moving forward through the big hose causes an equally powerful backward reaction. This reaction would knock the man off his feet if he weren't braced against it.

Deer

The deer's moving body pushes against the glass. Since the glass quickly breaks, it doesn't slow the deer's motion very much. The force of impact, therefore, is not great enough to injure the deer. Nor is the deer's face cut, for it touches only the flat part of the glass. The deer's motion then tends to push the pieces of glass outward in straight lines. If the deer is moving fast enough, it may pass through the pieces before there is time for any of them to fall on him. As a result, the deer may escape injury. All three of Newton's laws play a prominent role in the action of this photo. See if you can describe the role of each of these laws in greater detail.

Parachutist

Before bailing out, the parachutist was traveling at the helicopter's speed. When he jumped, his forward speed tended to stay the same. Thus, while falling, he moved forward about the same distance as the helicopter. This is explained by Newton's first law — the tendency of a moving object to remain in motion.

Dinner in mid-air

This picture also illustrates Newton's first law: an object at rest tends to remain at rest. When the sled was catapulted rapidly forward, the dinner remained where it was. It hung momentarily in mid-air until the force of gravity made it fall. The parachutist picture illustrated another aspect, the tendency of a moving body to remain in motion.

Football

When the ball is kicked, the air inside it is compressed and the foot penetrates into the ball. The compressed air tends to expand the ball to its original shape even as the foot pushes the ball. Both the compression and expansion take time. As a result the foot pushes the ball for a longer time than it would if there were no air in the ball. This gives the ball more speed and it goes farther.

Newton's second law helps explain this. Since the force of the foot acts on the ball for a longer time, the ball will be accelerated over a longer period. It therefore will gain more momentum.

Firemen with net

By the time the jumper hits the net, he will have developed a great deal of momentum because of his weight and high speed. It would normally take a tremendous force to stop his body. And such a force would injure him. So the firemen put Newton's second law to work.

They hold the net high. When the man hits it, they let it move downward. By thus allowing more stopping time, they reduce the force needed to stop him. The softness and flexibility of the net also help reduce the force of impact. This and the football photo show different effects of applying a force for a longer time.

Newton's laws of motion

Newton's three laws of motion may be stated as follows:

1. An object tends to resist any change in its state of motion. If at rest, it tends to remain at rest. If in motion, it tends to remain in motion.

2. The change in the velocity of an object is proportional to the force applied to it and the time during which the force acts.

3. To every action, there is an equal, opposite reaction.

John Dalton: First atomic scientist

By Rose Wyler

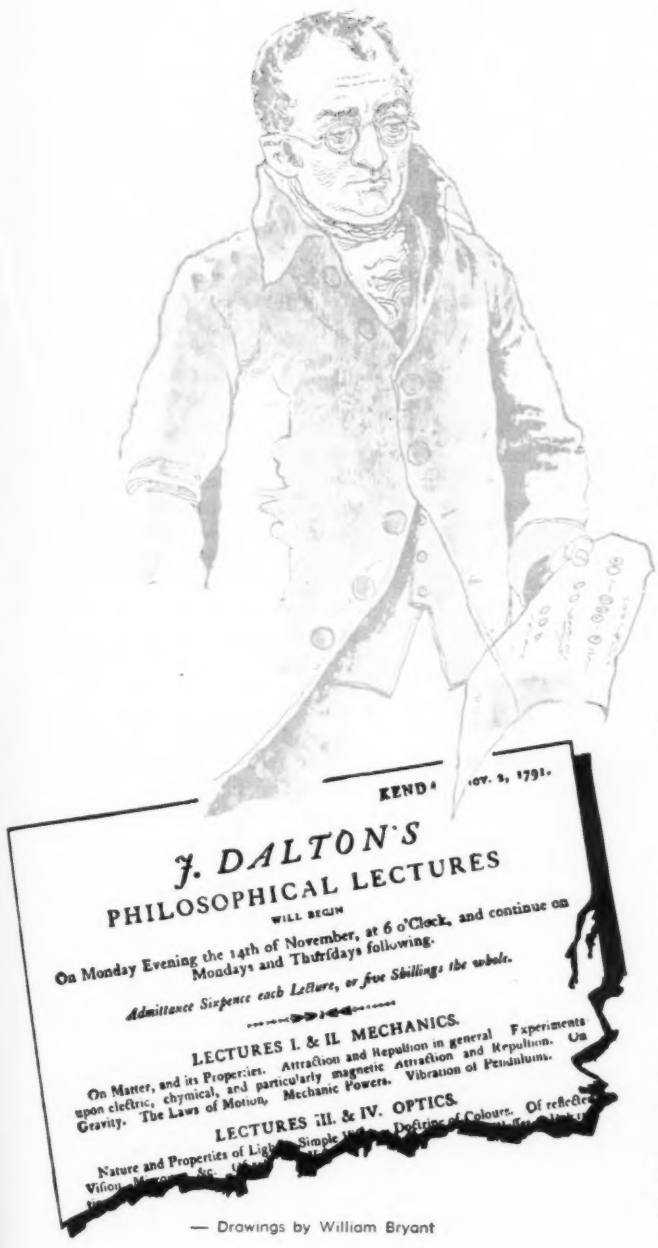
John Dalton (1766-1844), the father of the atomic theory, was about to be presented to the King of England. Custom required the wearing of lavish robes and a sword. But Dalton was a Quaker, and, according to his principles, always dressed simply.

A solution occurred to him. On the day of the ceremony, he covered his Quaker clothes with the gown he had worn to accept an honorary degree from Oxford University. As he marched down the aisle, no one noticed the absence of the sword. But his friends stared at the gown. "Why, it is scarlet!" one of them exclaimed. "Though to thee it is scarlet," Dalton replied, smiling, "it is not so to me. It is green, the color of leaves." And it was with good conscience that Dalton could say this, for he was color blind.

Color blindness was one of the first subjects that Dalton had investigated. The report he wrote on his findings attracted so much attention that color blindness was called "Daltonism" for many years.

From boyhood, Dalton had been fascinated by mathematics and all branches of physical science. He delighted in sharing his knowledge with others, so — naturally — he became a teacher. When he was only twelve, he was already teaching in a school conducted by the local Quakers in his native village of Eaglesfield. At fifteen, he left home to teach in a cousin's school in Kendal, where he stayed for twelve years.

In Kendal, the study of weather became his hobby. He spent hours making thermometers, barometers, and other meteorological instruments. Several times each day, he


KENDAL ... Nov. 2, 1791.
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LECTURES III. & IV. OPTICS.
Nature and Properties of Light. Simple ... Doctrine of Colours. Of reflected Vision ...

— Drawings by William Bryant

would take temperature, pressure, and humidity readings, then record them in a notebook.

Too poor to afford all the books he wanted, Dalton satisfied his curiosity by experimenting. One question that bothered him was how water enters and leaves the atmosphere. The belief of the times was that when water evaporates, it combines chemically with the air. However, Dalton was able to disprove this and show that both evaporation and condensation are simply changes in the physical state of water.

In 1793, when Dalton was 27, he published the results of his studies in his first book, *Meteorological Observations and Essays*. That same year he received an appointment to the faculty of a college in the bustling mill city of Manchester. Moving was easy, for he was unmarried and had few possessions other than his notebooks and instruments. He found room and board with a congenial Quaker family, and this arrangement turned out to be so pleasant that Dalton continued it for the rest of his life.

In Manchester, Dalton joined the city's Literary and Philosophical Society. This name was deceptive, for the main concern of its members was science. These men were quick to recognize Dalton's talents and gave him help and encouragement in his work.

Dalton was soon spending all his free time in his laboratory. His only tools were his precious thermometers and barometers, a few flasks, a balance, a gas-measuring apparatus called the eudiometer, and some bottles filled with common chemicals. But Dalton made this simple equipment serve him well. With it, he formulated a theory to explain how chemicals combine in terms of their invisible units called atoms.

Stroke of genius

Just how did he do this? Oddly enough, Dalton himself couldn't quite remember. He gave his friends three different accounts, but all were contradicted by his own records. Long after Dalton's death, a dusty pile of laboratory notebooks was unearthed in the cellar of the Society's headquarters. Scholars studied them, but even they found it hard to retrace the course of Dalton's reasoning. (Very likely, the question will never be settled, for Dalton's notebooks were destroyed in the bombing of Manchester during World War II.)

Dalton probably followed many clues on the trail of the atom. The first one, it seems, came from an experiment he had done in studying the atmosphere. He had found that when a light gas is poured on top of a heavier one, it does not stay there as cream floats on milk; instead, the two gases become completely mixed. The only way he could explain this was to assume that gases are made of tiny, invisible particles that move around and intermingle.

The idea that matter is made of invisible particles was by no means new. It was proposed as early as 400 B.C. by the Greek philosopher Democritus, who named the particles atoms. But very little was made of this idea until Dalton's time. It was his work that presented the atom as a definite physical and chemical entity.

From the writings of the great French scientist, Lavoisier, Dalton had learned to distinguish between elements and compounds. An element, he knew, could not be broken down into simpler substances, but a compound *could* be broken down into two or more elements. Lavoisier had found that nitrogen and oxygen are elements, but water and carbon dioxide are compounds that contain two elements.

Dalton made use of these facts in developing his theory of particles. Nitrogen and oxygen, he said, must be made of simple particles — or atoms — that cannot be destroyed in chemical analysis. Carbon dioxide and water, on the other hand, must be made of more complex particles containing atoms of two different elements.

Dalton soon became convinced that each element was made of atoms. Since each element was different from all the others, it followed logically that its atoms were different from the atoms of all the other elements.

The work of a second French scientist, Proust, gave Dalton another clue. Proust had shown that, in each compound, the elements always occurred in the same proportions by weight. But why? Dalton sensed his atoms would provide the answer.

Just how much did each kind of atom weigh? Take nitrogen, for example. Since nitrogen is somewhat lighter than oxygen, Dalton reasoned, its atom must be lighter than the oxygen atom. And the hydrogen atom must be the lightest of all. Of course, Dalton knew he could never hope to weigh single atoms. All he wanted to do was learn their relative weights, which would serve just as well.

As a standard for comparison, Dalton chose the lightest element, hydrogen. His experimental evidence showed that the proportion by weight of hydrogen to oxygen in water was 1 to 7. Assuming that one atom of hydrogen combined with one atom of oxygen, he concluded that the oxygen atom must be seven times heavier than the hydrogen atom. (As we now know, the ratio by weight of hydrogen to oxygen in water is about 1 to 8. And water is formed by the combining of two hydrogen atoms with one of oxygen. So the difference in the weights of the atoms is about twice as great as Dalton thought — 1:16. Nevertheless, his method was right, and he made good use of it.)

After analyzing many compounds, Dalton worked out a table of relative weights for fourteen elements. This table, the first of its kind, was presented in a paper that he read before the Society in 1803. In the years that followed, he refined the table and managed to bring his figures closer to the true relative weights of atoms.

'Simple' deduction

As Dalton went on analyzing compounds, he found that in each case the proportional weights of a compound's elements are always in simple ratios. For the gas now called carbon monoxide, the ratio of carbon to oxygen turned out to be 3:4. For carbon dioxide, the ratio came out 3:8. Now 3:4 was close to the ratio of the relative atomic weights that Dalton had obtained for carbon and oxygen. The meaning of this was unmistakable.

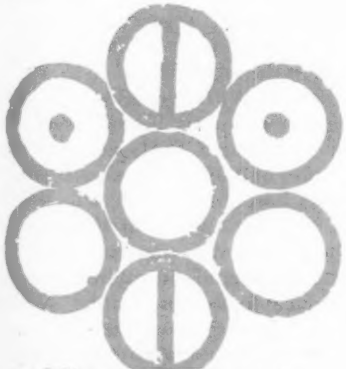
In the formation of carbon monoxide, one atom of carbon combines with one of oxygen. In carbon dioxide, one carbon atom combines with two oxygen atoms. It was as simple as that!

To clarify his theory, Dalton began to diagram the structure of various compounds. Using a dot as a symbol for the carbon atom and a circle for the oxygen atom, he drew this portrait of the smallest carbon monoxide particle:

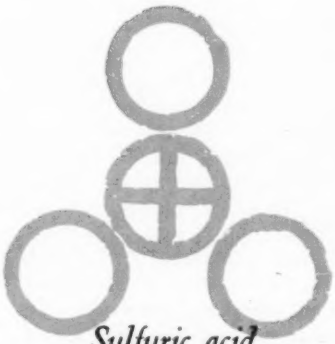
To illustrate a chemical reaction, Dalton merely shifted his symbols around. The rearrangements represented the changes that, in his opinion, occurred when new products form. Dalton assumed that in every chemical change the atoms remained intact, acting as whole units. Though there was no direct proof for this assumption, it fitted the facts. It neatly accounted for the fact that the weight ratios of the elements in a compound could be expressed in simple whole numbers.

Dalton presented his atomic theory in a book called *A New System of Chemical Philosophy*. This masterwork appeared in 1808 and quickly became famous. Honors and medals were heaped upon Dalton, but he continued to live as simply as ever. More important than fame to him was the knowledge that other scientists could build on his atomic theory and use it as the cornerstone of chemistry.

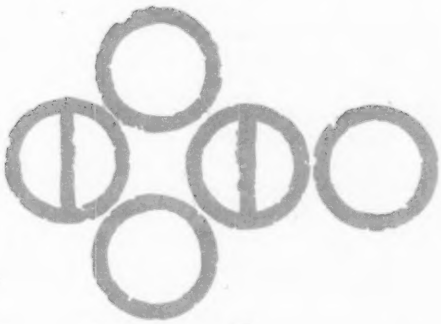
TABLE OF ELEMENTS at right shows symbols used by Dalton to represent atoms and his estimates of relative atomic weight. *Below,* three of his 'compound atoms' (molecules).



Nitrate of ammonia



Sulfuric acid



Nitrous acid

By Lynn Poole

TELLTALE TREES

A new method of prospecting for minerals has been worked out by scientists. Trees and plants are the key.

Flying over a desert area in a single-engine plane, two geologists looked down with trained eyes at shrubs and scrub. After an hour's flight, one of the scientists scribbled a note, "Bore for probable deposit of copper."

Scientists in another plane, flying over a mountain region, sent word to a ground search party, "Gold-bearing vein possible."

From a helicopter hovering over a hilly wasteland, a scientific observer radioed one word, "Uranium."

Detection by geobotany

These prospecting scientists were putting into practice one of the newest methods of locating mineral deposits. The science of geobotany (rocks and growing things) has proved that growing things indicate not only the location of minerals but also the amount and richness of the mineral and the outlined area in which it may be found. In co-ordination with other scientific methods of prospecting, geobotany is making it easier and faster, for geologists to locate sources of minerals. It is based on the fact that deep deposits of minerals may be reflected chemically in surface vegetation.

On the North Fork of Watson Bar Creek, 6,000 feet up in the mountains of British Columbia, a mineral search party gathered tree leaves, branches, and pine cones and needles. Roots were dug up and boxed. All were carefully labeled. Back in a scientific laboratory, the forest samples were reduced to ash and put through a chemical process. Each sample was analyzed for mineral content.

The purpose was to discover whether there was a mineral in the ground that had been taken up by the roots, passed on to the branches, and absorbed by leaves, cones, and needles. And if a mineral was present in the ground, could it be profitably mined?

Study of the forest samples showed traces of gold. There were 4 parts per million traces of gold in the roots, 2 parts per million in the branches, and an average of 1.4 parts per million in leaves and pine cones. The geologists dug in the area from which the forest samples came. They found several gold veinlets well worth mining.

Douglas fir, dwarf juniper, lodgepole pine, yellow pine, and aspen were growing in this area. Each species drew up the same amount of gold from the ground. So now, geologists flying over an area containing these specific telltale trees have an indication that gold may be located beneath them. Other gold-bearing areas have since been located by this method.

Two elements, selenium and sulfur, are aiding geologists in the search for uranium and vanadium. Geiger-counter techniques, boring, and rock testing are expensive ways to look for important sources of uranium.

Scientists discovered, however, that wherever uranium and vanadium are found, the soil is also rich in selenium and sulfur, the "S. and S. twins." Geobotanists figured that, by exploring well-known uranium and vanadium areas, they could learn whether or not vegetation would provide a clue to the locations of the sought-after minerals.

At a test location around Grant County, New Mexico, geobotanists found tumble mustard, pepper grass, prince plume, and wild onion. These four plants are known to require sulfur for flourishing growth. In the same area there were twenty-one varieties of luxuriant milk vetch and quantities of woody aster and rice grass — all plants that thrive on selenium. Here was proof that the S. and S. twins existed in abundance in the uranium area.

Cuttings of each type and species of plant were burned to ashes, then chemically treated for the removal of selenium and sulfur. The residue was uranium. Again vegetation had proved an indicator of a desired mineral beneath the ground. But, the scientists wondered, could vegetation indicate how much or how little mineral was in the ground?

Roots of the trees in the area were tested next. To maintain life in a semi-arid land, such as that section of New Mexico, roots sometimes bore down 100 feet in search of moisture. Roots of the trees of the region were dug from as deep as possible and cut off at each successive foot downward. When tested in the laboratory, the roots gave stronger and stronger indication of the presence of uranium at deeper and deeper levels.

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Exactly the same sort of investigation was carried out in another area, where there were known to be small deposits of uranium. Here, the vegetation was scrubby and barely alive. The S. and S. content was low. The roots of the pathetically weak trees contained very little uranium. Scientists now knew for certain that plants indicate not only the *location* of minerals, but also their *concentration*.

Walking, flying, helicoptering over large areas, scientists continued to look at vegetation for evidence of mineral deposits. Quite by chance, they learned a third important fact about growing indicators.

The San Manuel section of Arizona, near Tucson, is rich in copper. Teams of geobotanists flew over the area to photograph the vegetation. They saw the evergreen Emory oak and the Mexican blue oak both growing to heights of twenty feet. Since these so-called scrub oaks grow only in soil where oxidized ore is abundant, their presence confirmed what the scientists already knew — copper was below ground.

The eyes and cameras of the flying geobotanists also saw thousands of the bright orange blossoms of California poppies. The area was covered with the flowers.

What the poppies showed

In the laboratory, chemical tests on twigs and roots of the two kinds of oak produced evidence of a heavy concentration of copper. The tested blooms of California poppies contained some copper, but not enough to excite the scientific prospectors. Nevertheless, as indicators the poppies proved to be as valuable as the oaks.

A careful study of the aerial photographs gave the scientists something to think about. The California poppies grew in profusion in the area where the San Manuel copper was concentrated. But just outside this area, where the copper content of the land decreased rapidly, there were only a few small, straggly poppies. The California poppies accurately, almost geometrically, defined the limits of the copper deposit. Prospectors who spot this kind of vegetation boundary need not dig beyond it in the hope of finding copper.

This investigation proved that certain visible vegetation can *outline* the area of mineral deposit, as well as *locate* and *evaluate* it.

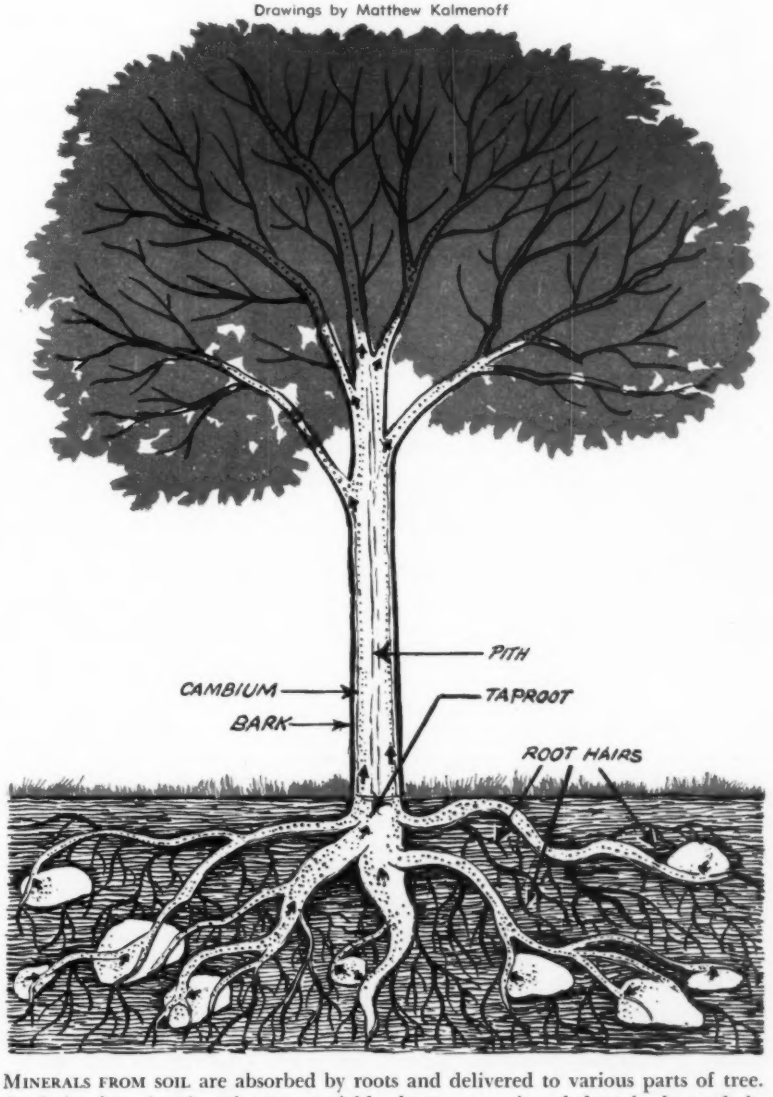
Uranium, vanadium, copper, gold, lead, zinc, and many other vital minerals today are being found, evaluated, and outlined by the sharp and experienced eyes of geobotanists. But there's much more to be learned.

Geobotanists want to know whether there is a "best" time of year for observing vegetation in the search for a specific kind of mineral. Hundreds of experiments must be run before seasonal scientific rules can be formulated.

Will color itself or intensity of color and hue be clues to minerals? What combination of vegetation indicates the deposit of what kind of mineral? Do height, strength, and thickness of telltale trees mean the presence and concentration of a mineral? Does the bright flowering of plants give affirmative or negative information?

As such questions are answered, geobotany will develop into a science that would amaze old-time prospectors who mined by guesswork with pick and shovel, pan and sieve.

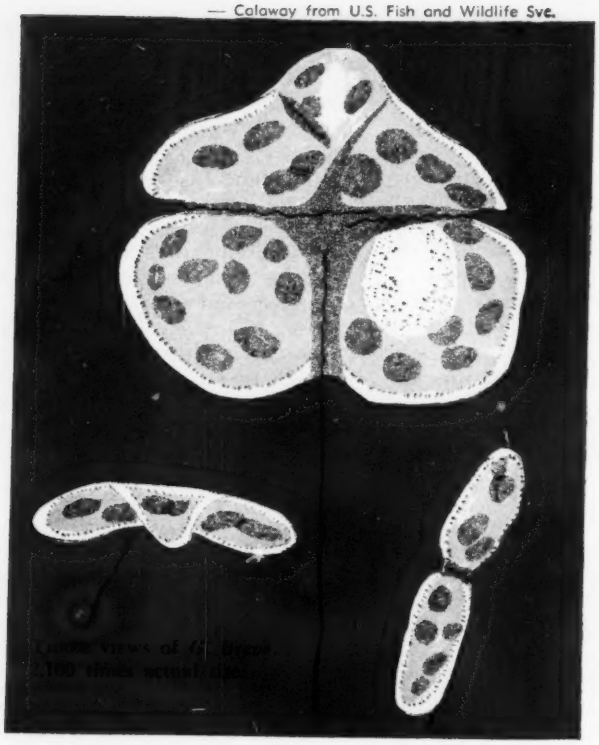
Drawings by Matthew Kalmenoff



MINERALS FROM SOIL are absorbed by roots and delivered to various parts of tree. Analysis of tree's mineral content yields clues as to mineral deposits beneath it.

by Lynn Poole, published by Whittlesey House. Copyright© 1958 by Lynn Poole.

— Calaway from U.S. Fish and Wildlife Sve.



Cluster views of *G. breve* 2,100 times actual size

By Roy A. Gallant

When patches of discolored water appear in the Gulf of Mexico, it is the death sentence for millions of fish and other marine creatures

Florida's red-tide mystery

On November 20, 1946, fourteen miles off Florida's west coast, mackeral fishermen saw a dreaded sight. Ahead of them, the normally deep-blue water of the Gulf of Mexico appeared reddish brown.

Light reflected from water can play tricks on the eyes. But as the fishing boat drew closer there could be no doubt. The water was definitely discolored. Further evidence of what was happening soon appeared. As the fishermen neared the dark water they saw more and more dead fish bobbing about.

The red tide had returned. This deadly disturbance of the Gulf's waters had plagued Florida off and on for more than a hundred years. Since 1844, there had been at least fifteen major outbreaks. Each time the red tide had slaughtered untold millions of fish, turtles, oysters, and other sea life. And it had released an irritating "gas" that caused spasms of coughing and sneezing in shore residents.

Soon after the fishermen spotted the new outbreak of the red tide in 1946, others reported that the patch of discolored water was growing steadily larger. By January, 1947, the red tide had expanded to Boca Grande Channel, about fifty miles north. On the way, it had swept past Sanibel and Captiva Islands, just off the coast at Fort Myers. Residents of these islands said that the lethal strip of dark water extended offshore for from five to eight miles. Beyond, the sea was clear and blue.

By January 29, the miles of gleaming beaches in the vicinity of Fort Myers were littered with millions of fish carcasses. There were about a hundred pounds of dead fish to every foot of shore line. Tom Wood, a pilot-biologist who works for the U.S. Fish and Wildlife Service, lives on Sanibel. As he described it, "With shovels, road scrapers, bulldozers, anything we could dig with, we buried the decaying fish in the sand to keep down the stench."

By February, 1947, the red tide had just about disappeared. All told, an estimated fifty to one hundred million pounds of dead fish had washed ashore. And how much more had been carried away by the currents was anybody's guess. But the end was not yet in sight.

Early in July, the red tide reappeared. Then, at the end of August, the dark waters disappeared again.

Despite its name, the red tide is not a tide at all. Nor is it necessarily red. While it appears red to some people, others see it as gray or simply dark. It is an oily scum made up of billions upon billions of free-swimming, tiny one-celled animals (protozoa) called *Gymnodinium breve*. Whenever these creatures suddenly appear in heavy concentrations, there are heavy fish kills.

"Red tides" are by no means peculiar to Florida's west coast. They have occurred around the world in ponds, lakes, reservoirs, and in sea

water for hundreds of years. India, Africa, southern California, Texas, Puget Sound, Peru, Japan, Luzon, the east coast of Australia, and other areas all have reported similar protozoan invasions — some red, others blue-green, amber, yellow, or orange. As far back as 208 B.C., the water of Lake Bolsena near Rome reportedly turned red.

In his book, *Voyage of the H.M.S. Beagle*, Charles Darwin reported on an 1832 red tide off Chile.

A red-pigmented alga known as *Trichodesmium erythraeum* gave the Red Sea and the Vermilion Sea (Gulf of California) their names. Few areas of the world, however, seem to be plagued with fish-killing tides as numerous as those occurring off Florida's west coast.

It wasn't until the 1947 outbreak that scientists launched an organized attack against *G. breve*, the killer organism. The Fish and Wildlife Service asked scientists of the University of Miami and the Woods Hole (Massachusetts) Oceanographic Institution to study the tide. One of the scientists' first steps was to identify the killer and learn all they could about its habits. In January, University of Miami biologist Charles C. Davis identified the organism as a dinoflagellate and named it *Gymnodinium breve*.

The creature is only one-thousandth of an inch in size. On the right side of its body is a single nucleus, while scattered throughout its body are pigment cells (chromatophores) that give the creature its color. The rest of the organism is more or less transparent, like an amoeba. It darts through the water by wiggling two whiplike threads (flagellums), one trailing behind, the other running around its middle.

One interesting thing about *G. breve* is that it has plant as well as animal characteristics. Like plants, it uses chlorophyll to manufacture food in the presence of sunlight. Whether or not it eats other microscopic organisms that live in the sea is not known. At the present time biologists are not satisfied with their knowledge about *G. breve*'s nutrient requirements or about its life cycle. Until one or both of these two riddles — life cycle and feeding habits — are solved there may be little hope of controlling the creature.

U.S. Fish and Wildlife Service biologists take periodic samples of sea water in Tampa Bay and elsewhere along Florida's west coast to keep count of *G. breve*. This is done by dipping a two-liter (2.1-quart) container into the sea and bringing the water sample back to the laboratory. The flask is then placed under a light. Because the organism is phototropic (turns toward the light), it swims to the surface. A biologist can then siphon off the organisms and count them under a microscope. One thousand organisms to a liter of water is considered a "light" count. A medium count is about 100,000 to a liter. And a heavy count is anything over 100,000.

When conditions are just right for the creatures, they begin to divide at a dizzying rate. Within a few days a small patch of them swimming in the sea can multiply to cover an area of several hundred square yards. When they begin to divide rapidly, they are said to be in "bloom." A bloom of 500,000 organisms to a liter is enough to kill fish. Three or four water samples taken during the summer red tide of 1947 counted out to between 50 and 60 million creatures per liter! When their concentration is this thick, the water has an oily appearance. "When dipped up and allowed to stand for five to ten minutes, it becomes thick, sometimes almost of a consistency of

— Saint Petersburg Evening Independent

FISH KILLED by red tide are sprayed with DDT and deodorant. During heavy fish kills, bulldozers are used to bury carcasses.

Karo syrup, and slimy to the touch," according to the Fish and Wildlife Service.

One of the major mysteries about *G. breve* is just how it kills its victims. Shrimp, oysters, barnacles, turtles, crabs, clams, mullet, snapper, sharks, redfish — all perish in a red-tide bloom. Biologists at one time suspected that thick concentrations of *G. breve* possibly clogged the gills of fish and so killed them by suffocation. But laboratory tests have cast some doubt on this idea. According to fishery biologist Paul S. Galtsoff, gill filaments of dead fish placed under a microscope appeared normal. They were not covered by an accumulation of plankton.

Another suggestion was that the organism possibly lowered the oxygen content of the water, thereby killing fish. This idea stemmed partly from fishermen's reports that dying fish swam to the surface and appeared to "gulp for air." But it also had to be discarded in the light of laboratory tests.

How it may kill

Now biologists are convinced that the organisms, when in bloom quantities, give off a toxin that poisons fish swimming through it. A fish entering a red-tide bloom and then swimming into clear water will die moments or hours later, depending on the concentration of *G. breve*. To date, chemists have not been able to isolate this poison and so identify it. They suspect, however, that the same poison that kills fish may also cause the coughing and sneezing spells in humans.

During a red-tide outbreak in 1916, Harden Taylor, Chief Technologist of the Bureau of Fisheries, described the "gas" in these words: "While on the beach I felt a slight tendency to sneeze and cough; shortly afterwards my attention was called to the dog, which was sneezing violently and seemed to be in acute asphyxiation . . . I then noticed that my lungs were feeling sore and that my breathing was labored in much the same manner as when I board ships after fumigation, except that I noticed no odor. [During the second tide outbreak a few days later] many people telephoned for medical assistance for 'cold in the head,' 'sore throat,' and 'cold in the chest.' I myself have suffered quite acutely for the past five days, but the worst of the gas seems to be going now."

The "gas," which is odorless and colorless, troubles people only when there is an onshore breeze. The wind apparently carries tiny droplets of water containing the poison through the air. Like water droplets in steam, they enter the eyes, nose, and throat. According to one observer, cotton held over the nose and mouth will filter out the toxin and so prevent irritation.

The red-tide "gas" has long provided unthinking people with an easy explanation of the tide. When a severe bloom kills fish, someone is bound to revive a favorite story that goes like this: After World War I (or World War II), the Army disposed of thousands of drums of poisonous gas by dropping them into the Gulf of Mexico. Some of the drums are just "now" (time of a red-tide outbreak) rotting through and leaking the gas into the Gulf. Hence, the fish kills.

The facts do not bear out this idea.

No control to date

Is there any way to control the red tide? And is there any way to predict when it will strike? To date, no. Biologists have found that a copper sulfate dust spread over a red-tide bloom will kill the organisms. But they are not sure what other marine life it will also kill. In addition, there is the expense and difficulty of applying the copper sulfate dust. How do you effectively dust hundreds of square miles of ocean every time there is a bloom — even if you can afford to do so?

In their efforts to predict when a red tide will come, biologists and chemists constantly take samples of Florida's west-coast waters. Each time they take a sample they note meteorological conditions, salinity and acidity of the water, its temperature, and so on. By keeping these records both in normal times and during red tides, they may eventually discover just the conditions the organisms require to bloom. With this knowledge they should then be able to control *G. breve*.

According to S. H. Hunter and John J. A. McLaughlin of New York's Haskins Laboratories: "Some poisonous [dinoflagellate] blooms may generate their explosiveness by a biological chain reaction: the poison kills fish: decaying fish increase the supply of nutrients in the water: the increase in nutrients yields a larger number of dinoflagellates: they make more poison . . . and so on." This idea was originated by Albert Collier, formerly of the U.S. Fish and Wildlife Service.

Clue from nutrients

One of the nutrients scientists are looking to for an explanation of Florida blooms is phosphorus. Marine biologist Bostwick H. Ketchum has reported unusually large amounts of phosphorus in samples of Florida's red tide. Some chemists and biologists now suspect that after heavy rains, rivers and streams wash large deposits of phosphates (abundant in Florida) into the waters along the coast. A possible result, according to a Florida Board of Conservation report: "The fertilizer-like minerals (such as phosphates) can fertilize coastal areas of the sea and thus cause dinoflagellates to reproduce at enormously rapid rates. This rapid reproduction may result in the tremendous populations that constitute red tides."

But phosphates alone are not enough for dinoflagellates to grow on. Other salts, such as nitrates and nitrites, are also needed. The nutrient secrets of the red-tide organism have thus far eluded scientists. Until scientists can penetrate these and other secrets of *G. breve*, Florida's west coast will probably continue to be plagued.

There is one encouraging note for Florida's west-coast residents. Last year, a permanent laboratory was set up in Pass-a-Grille by the Fish and Wildlife Service. From now on, red-tide research will be carried on intensively. Though the purpose of the new lab is to watch over *all* commercial and sport fishing interests, its scientists are not for a moment going to overlook the red-tide mystery.

Sally Johnson of Philadelphia, Pennsylvania, writes:

Do man-eating lions really exist?

Many cases of man-eating lions have been reported. One particularly famous one occurred in Africa in the 1920's. Over a period of months, two lions devoured twenty-eight overseers and an undetermined number of African natives who were building a railroad. As a general rule, however, lions will not go out of their way to attack a man unless they are pursued or in a wounded condition.

Merill Resnick of Bronx, New York, writes:

What causes "blue babies"?

"Blue babies" suffer from a lack of oxygen in their blood. When either of two ducts in the heart fails to close at birth, the child's blood goes directly from the right to the left side of the heart. It does not pass through the lungs, as a normal person's does, to pick up its oxygen supply. Without oxygen, the blood turns a dark color, which causes the skin to become bluish. This skin condition is known as cyanosis.

Rosemary Zickerman of Fort Atkinson, Wisconsin, writes:

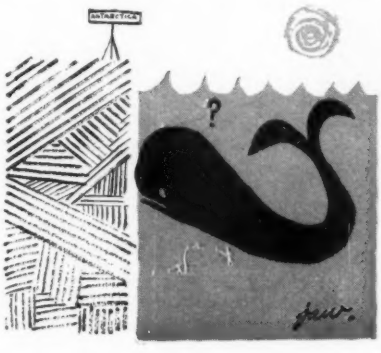
I have often seen rotifers under a microscope, but I have never seen *Euglena*. Where can I find some?

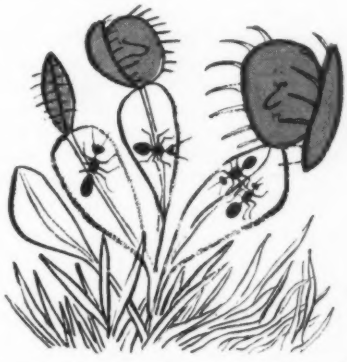
Euglena are found in fresh-water ponds and marshy parts of lakes and streams. Sometimes they are so numerous they form a green scum on the water's surface. Your chances of seeing *Euglena* are best if you collect some of this surface scum. Unlike rotifers, *Euglena* are one-celled organisms. They are popular microscope subjects because they show both plant and animal characteristics. They can manufacture their own food, as plants do. And, like animals, they have a mouth and gullet to swallow and digest food.

Myron J. Malecha of Montgomery, Minnesota, writes:

How large must a body of land be before it is considered a continent? How large is Antarctica? Is it a continent?

A continent is a large continuous mass of land. Most geographers agree that there are six continents: North America, South America, Asia, Africa, Australia and Antarctica. No exact size is required to qualify a body of land as a continent. Australia, which measures 2,948,366 square miles, is the smallest continent. Antarctica is approximately 6,000,000 square miles. But recent IGY findings indicate that it may not be a continent at all. Under the vast antarctic ice sheet, there may be a chain of islands rather than a solid land mass.





Bob Murphy of Los Angeles, California, writes:

Do plants that eat animals ever get indigestion?

Surprisingly enough, they do. Overeating can be a problem even in the plant world. Two plants that trap and eat animals, Venus's-flytrap and the sundew (see *SW*, September 25), sometimes have digestive troubles. If their diet is too heavy, they droop, temporarily fade in color, and lose their appetites.

Questions from readers will be answered here, as space permits. Send to: Question Box, Science World, 575 Madison Avenue, New York 22, N.Y.

Lunar rocket opens way for safe space travel

Pioneer's swing through space took it only a third of the way to its goal, the moon. But the lunar-probe rocket chalked up some impressive technical and scientific achievements:

- It flew faster and farther into space than has any other man-made vehicle. Pioneer's top speed was 34,400 feet per second (about 23,450 miles per hour). This was about 800 feet per second short of the speed needed to carry it to the moon. The rocket reached a record altitude of 77,000 statute miles (or 67,000 nautical miles).
- Pioneer measured for the first time radiation in space above 2,500 miles. The measurements revealed that radioactivity at higher levels is not the serious threat to space travel that man had feared. The Explorer satellites had reported earlier that intense radiation existed several hundred miles above the earth. Pioneer confirmed this. But the rocket reported that the radiation began to lessen at about 10,000 miles up and continued to do so as altitude increased. Scientists now suspect that the radiation at lower altitudes comes from charged particles trapped in the earth's magnetic field.
- Pioneer measured the earth's magnetic field at altitudes never before reached. Spot-checks of the rocket's mass of data tended to confirm scientific theories about the structure of the magnetic field. (See drawing on this page.)

Pioneer also carried instruments to record the impact of meteoric particles. Only one impact was registered during the first fifteen hours of flight. This could mean that such particles pose little danger to space flight. But the figure was suspiciously low. Possibly the recording instruments weren't working properly.

While still processing data from this Pioneer, Air Force scientists were getting ready to launch another one this month. The Army will make two lunar probes, the first in December or January. Last month, the Army tried to put a twelve-foot balloon-satellite into orbit, but the launching rocket failed to work properly.

Scientists to dig hole in floor of ocean

Scientists are making plans to drill a three-mile-deep hole in the ocean floor. Their purpose is to learn more about the earth's early existence. A committee from the National Academy of Sciences will choose a site and assemble data to determine whether the project is feasible.

The scientists plan to use oil-well-drilling and rock-mining techniques to bore through layers of sediment to the mysterious "Moho." Moho, short for Mohorovicic Discontinuity, is the boundary between the earth's crust and the highly compressed rock beneath it. (Mohorovicic, a Yugoslav scientist, first identified it.) The Moho is located about 20 miles under the surface of land. But it is only a few miles below the ocean floor. So it's easier to reach through the ocean floor.

Geologists have subdivided the earth's interior under the crust into three layers: (1) an outer mantle of rock about 1,800 miles thick; (2) a core about 1,360 miles thick, composed of molten iron and nickel; and (3) an inner, more solid core that has an estimated radius of 815 feet.

Under the ocean floor, geologists suspect, lies a record of the past life and climate of the earth, deposited in layers of sediment. By examining cross-sections of these layers, the scientists hope to piece together a picture of the earth's early history. The sediment may extend as far down as 3,000 to 4,000 feet. Below that, the scientists hope, is the earth's surface as it was when the oceans were first formed. By penetrating this surface, they hope to find clues to the earth's origin.

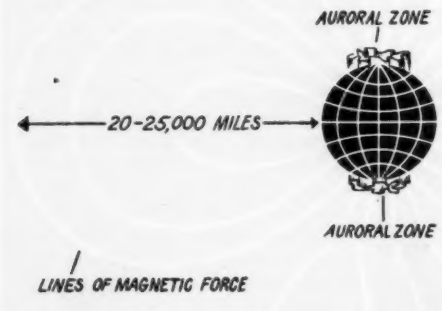
Rockets save the day during solar eclipse

It was a disappointing day for the group of scientists in the South Pacific. They had gathered on the Danger Islands, about 350 miles northeast of Samoa, to study the eclipse of the sun on October 12. But thunderstorms blotted the sun from view. The poor weather spoiled the planned study of the solar corona. This faintly glowing outer atmosphere of the sun comes into view only during an eclipse.

But the day wasn't a total loss. During the time when the moon was passing between the earth and the sun, five rockets were launched, to altitudes of from 55 to 150 miles. They measured solar radiation during various stages of the eclipse. This data was radioed back to the scientists. It is expected to reveal new facts on how the sun affects the upper atmosphere and what this does to radio communications.

The total eclipse lasted about four minutes. It threw a shadow across the Pacific from east of New Guinea (where the sun was then rising) to a point inland from Santiago, Chile (where the sun was setting). It was not visible in North America. Next total eclipse of the sun will be seen in October, 1959, along Africa's east coast.

—LoCurcio



Classic view of earth's magnetic field was supported by data sent from Pioneer rocket. Lines of force may form loops only up to auroral zones circling poles.

—Wide World

High-powered rocket ship, the X-15, was recently unveiled. It's expected to carry man more than 100 miles high — to the fringes of space — at speed of 3,600 mph. Craft will test man's reaction to weightlessness and to other space-flight conditions. First test flight will be early next year. Liquid nitrogen will pressurize craft and keep various parts cool. X-15 is 50 feet long, has 22-foot wing-span.

Navy balloon flights to study planets

The Navy is conducting a series of balloon flights to observe the planets, the sun, and possibly the stars. A manned balloon is scheduled to be sent sixteen miles above the earth this month. Its purpose: to find out how much water there is on Mars, by spectographic studies.

This has long been a matter of dispute. Some astronomers think that the white polar caps sometimes observed on the planet indicate the presence of water in the form of snow. Others think the planet is almost completely arid. A telescope, spectograph, and other instruments mounted on top of the balloon may settle the argument. Later, the Navy plans to measure the oxygen content of the Martian atmosphere.

A balloon-borne telescope equipped with a television camera will soar into the stratosphere in 1961. Called Stratoscope II, the Navy's 36-inch telescope will photograph planets and other celestial bodies from 80,000 feet. There, it will be above the murky layer of the earth's atmosphere that generally blurs astronomical photographs. Last fall, scientists sent up a balloon carrying a 12-inch telescope (Stratoscope I). Photographs of the sun taken through it were sharper than any ever taken from the ground. More flights with Stratoscope I are planned for next summer. These flights are unmanned, for the breathing of a living passenger could easily jiggle the telescope enough to distort the photographs.

Eavesdropping scientists hear fish 'talk'

Some fish "talk" more than others. . . . Fish that live in salt water seem to be noisier than fresh-water fish. . . . Warm-sea fish make a larger variety of sounds than their cold-water cousins. . . . The spiny lobster makes two sounds: a rasp when it is disturbed and a rattle when it isn't. And, as in the case of man, the "voice" of the spiny lobster gets deeper as it matures.

Scientists have uncovered these bits of information by eavesdropping on the sounds made by fish and other marine animals.

So far, however, this scientific snooping has produced more questions than answers. For instance: Why do fish "talk" and how do they listen? What meaning, if any, do their "conversations" have? Marine biologists the world over are trying to find answers to these questions.

Underwater sounds can pose a problem to man. During World War II, for instance, fish noises mistaken for enemy craft sent many a submarine on a fruitless chase. And a single call of a common toadfish was enough to trigger an acoustical mine that had been designed to go off at the sound of a passing ship.

Using a special microphone called a hydrophone, scientists are now compiling a vast sound "library" of these strange noises from under the sea. After the hydrophone has picked up the sounds, they are taped, magnified, and fed into a machine that graphs them for study.

News in brief

● Your brain needs more sleep than your body does. Studies at the California Institute of Technology show that the human body can go for days without sleep and suffer no real harm. Not so the brain. Because of the complexity of their jobs, the brain's nerve cells can't renew themselves as readily as the nerve cells of the body. Lack of rest causes no important change in muscle tone, blood pressure, or heartbeat. But it immediately affects mind and personality.

● The U.S. atomic submarine *Seawolf* has set a new underwater record: it stayed submerged for 60 days. The previous record — 31 days, 5½ hours — was set last May by the *Seawolf*'s sister sub, the *Skate*. The *Seawolf*'s 116-man crew lived cut off from the earth's atmosphere longer than had any other human beings. The *Seawolf* engaged in "tactical exercises" during its voyage of 14,500 nautical miles.

● Some 600 balloons were released from cities all over the country as part of "Exploration Air Stream." This project was set up to show how easily polluted air could spread across the nation. The helium-filled balloons carried Russian as well as U.S. labels — just in case any of them drifted over Russia. (In the past, the Soviet Union has complained that we have used balloons to spy on that country.) The balloons also gathered scientific data on air currents.

● New York City's aquarium was hard-pressed to find a cure for Olaf, the red-eyed walrus. Efforts of a veterinarian and an eye specialist failed to correct the bloodshot condition of Olaf's eyes. Since Olaf is the only walrus in captivity in the Western Hemisphere, the aquarium asked the advice of the Alaskan Fish and Game Service, where walruses abound. A little embarrassed, but much relieved, the aquarium learned that there was no cure for Olaf. All walruses are red-eyed, said Alaskan scientists.

● The weatherman's job may soon be partially taken over by robots. Mechanical weather observers now being developed will funnel information at the rate of 1,000 words per minute to electronic computers. Within minutes, the computers will digest the information, prepare forecasts, and draw national weather maps that will be transmitted all over the nation. Human forecasters will concentrate on local weather.

Young scientists

GROWING CRYSTALS

— Drawings by LoCurcio

Since the dawn of human history, man has been fascinated by the symmetry of crystals. These shining, beautifully shaped bits of rock have been found where cave-man collectors stored them. Their definite shapes are in contrast to the apparent jumble of the rest of the inorganic world. To early man, this seemed to carry meaning.

Today, we have begun to understand that meaning. From the knowledge, we have learned much about atomic and molecular structure. We have also learned to create crystals and have found many uses for them. The transistor in a portable radio, for example, is basically a man-made crystal. Its properties are explained by our knowledge of crystalline structure.

Do you know what rock candy is? It is a clump of large sugar crystals. Why not try to make some? Here's how:

Wash a beaker thoroughly. Fill it a little more than half full of sugar. Pour in warm water, stirring constantly, until the beaker is filled to within a half-inch of the top. Pour the mixture of sugar and water into a saucepan. Heat it until the sugar is entirely dissolved and a clear syrup is formed. Allow the syrup to cool. Wash and dry the beaker. Pour the clear, cool syrup into it, being careful not to splash the sides of the beaker.

Now tie a piece of clean string to a glass rod or small stick. Place the rod across the beaker so that the string

hangs down into the syrup. The string should not touch the bottom of the beaker. Tie a piece of thin cloth over the top of the beaker. This will keep dust out of the syrup, but will allow the water to evaporate. Set the beaker where it will not be disturbed. It may take several weeks before crystals form.

In growing sugar crystals, you start with a solution that contains just about all the sugar the water can hold. As the water evaporates, a point is reached at which the water can no longer hold all the sugar. This is the saturation point. As evaporation continues, the sugar is slowly deposited on the string. At first, a few "seed" crystals are formed. Others are formed around these. As the crystals grow larger, they intertwine.

Now, suppose you want to grow a *single* large crystal. There are two requirements: (1) the deposits must build up slowly over a long period of time; and (2) you must start with one small "seed" crystal on which the material can be deposited.

Evaporation results in a slow rate of deposit, satisfying the first requirement. But evaporation takes place at the surface of the solution. The solution therefore becomes more concentrated at its surface. As a result, *several* seed crystals tend to form there. Material will deposit around these crystals. So, instead of one large crystal, there will be a number of smaller ones, as in the rock candy.

There is, however, a way of meeting the two conditions necessary for growing one large crystal. Most substances are more soluble in warm water than in cold. Suppose, then, that we make a saturated solution, using warm water. As the water cools, it will become supersaturated. The excess material will be deposited on any available nucleus. If a single seed is available, a large crystal can be grown.

To make a larger crystal, use alum that is already in crystalline form. Select the largest intact crystal. This will be the seed. Tie a piece of sewing thread to the crystal. Dissolve 75 grams of alum in 500 cc. of water at 75° C. Pour the solution into a Mason jar. Attach the thread to the cover of the jar so that the crystal hangs about an inch from the jar's bottom. After the solution has cooled to room temperature, transfer the jar to the refrigerator. When the crystal has grown as large as possible, remove it carefully from the solution.

Use the same technique to grow a crystal of sodium chlorate. Make the solution by dissolving 500 grams of sodium chlorate in 500 cc. of water at 75° C.

Metals also form crystals. Prepare crystals of metallic lead as follows:

Select a cork that fits a test tube. With a razor blade, cut a slit lengthwise in the cork so that a piece of string can be drawn to the center of it. Tie a strip of zinc to the string. Suspend the zinc in a 10 per cent solution of lead acetate in a test tube. Use the cork as a stopper for the tube. Crystals of lead will form in the shape of a "lead tree" (they actually look like a tree).

The lead tree is in the isometric system. This is one of six main systems (or groups) into which crystals are divided, according to their form. The other systems: tetragonal, orthorhombic, monoclinic, triclinic, and hexagonal. A study of crystal systems is fascinating. It should be of special interest to geometry students.

Interesting energy changes take place during crystallization. To illustrate, try this experiment. Obtain some sodium thiosulfate from your local photographic supply store. This salt is more commonly referred to as "hypo." It is quite inexpensive. Fill a test tube one-third full of hypo. Add five or six drops of water. Heat the salt over a Bunsen-burner flame until you get a clear liquid. While the solution is still hot, set the test tube upright in a test-tube stand, and cover its mouth with a piece of paper. Allow it to cool to room temperature. If no dust particles, crystals of hypo, or other nuclei of crystallization are present the solution will remain clear and water-like.

Now lift the cover carefully and drop in a grain of hypo. Immediately, crystallization begins — not only around the grain you dropped in, but also at the point on the surface where the grain entered. Watch closely, since the entire solution may crystallize very quickly. Feel the test tube. Before crystallization began, the solution was at room temperature. It is now considerably warmer. When they crystallize, some materials give out energy in the form of heat. Other materials take in heat, thus lowering the temperature.

Much could be written about crystals and what we can learn from them. As a basis for a project or exhibit, they offer many possibilities. You could, for example, prepare an exhibit on methods of growing crystals. You also might study crystal systems and explore their geometry. Or you might actually grow examples of each system. Finally, a study of materials that give out or take in heat during crystallization could prove fascinating.

— THEODORE BENJAMIN

Homemade motors

Here are two novel types of motors you can build

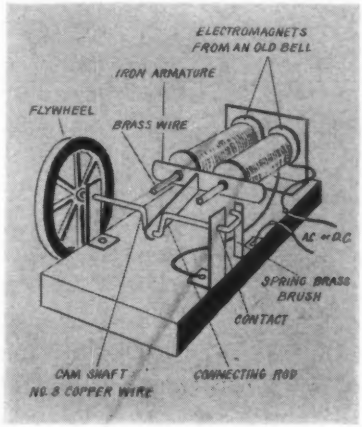


Fig. 1

1. In operation, the motor shown in Fig. 1 looks somewhat like a steam engine. The electromagnetic coils are taken from an old electric doorbell. A hole is drilled in the center of each of the pole pieces, and a short length of heavy brass wire is forced into each. It is on these two supports that the iron armature (also obtainable from the bell) rides. Solder the connecting rod to the armature, and have it operate the crankshaft. Bend the contact, which energizes the electromagnets, at right angles to the plane of the crank throw on the camshaft. Be sure to use a heavy flywheel.

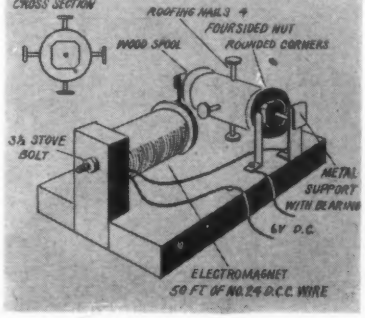
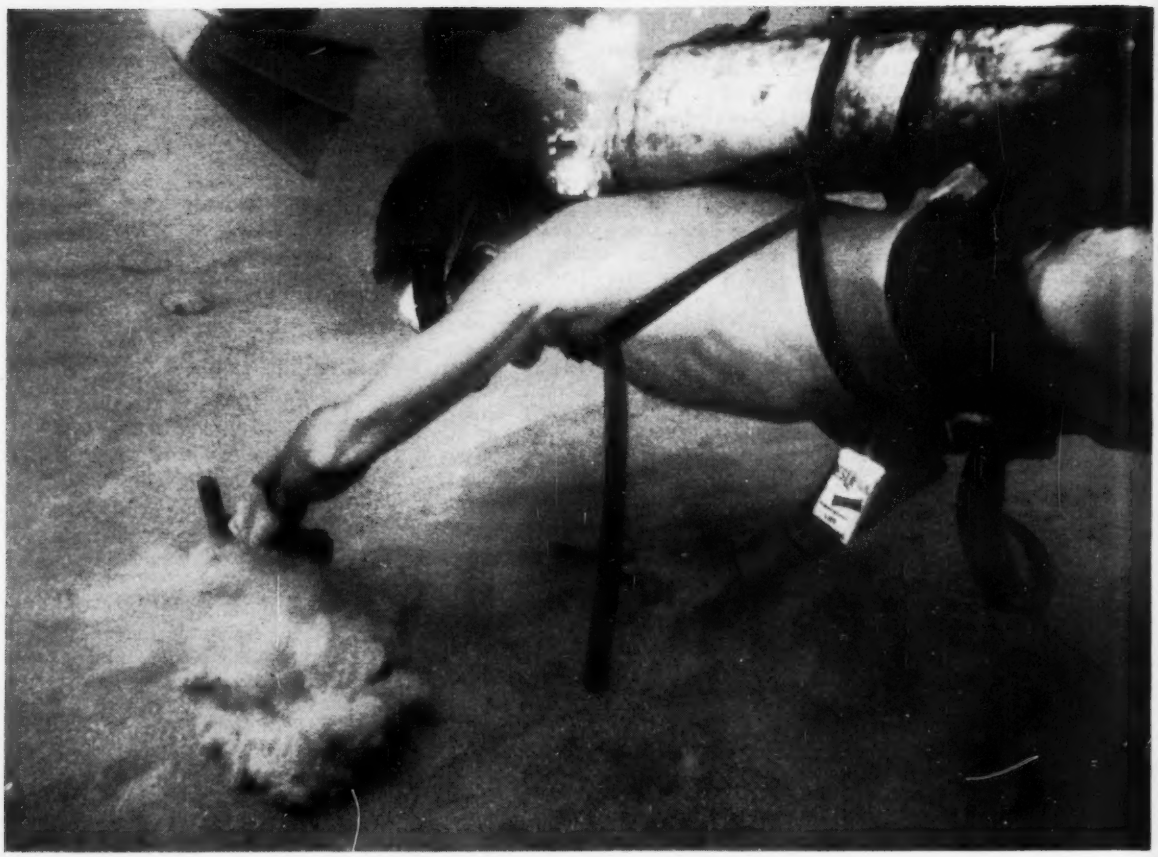


Fig. 2

2. Four iron roofing nails set in a wooden spool form the armature of the motor shown in Fig. 2. The "commutator" is a four-sided nut with corners rounded. The brush, which makes contact with the corners, energizes the electromagnet. Be sure to set the nut so that it will be at a 45° angle to the square formed by the nails.



THIRTY-FIVE FEET DOWN in Gulf of Mexico, geologist searches for specimens on ocean floor. — Socony Mobil Oil Co., Inc.

Skin-diving for tomorrow's oil

Careers

GALVESTON, TEXAS — Dr. Henry Nelson was walking along the bottom of the Gulf of Mexico one day when he heard a strange noise. He looked around, but no one was near. Yet a tiny *click!* had broken the vast stillness of the undersea world.

The geologist looked down at the ocean floor and saw that the noise was only a clam, shutting its shell.

But Dr. Nelson was not down there just to make the clams clam up. With the five other members of a skin-diving geological team from Magnolia Petroleum Company's Field Research Laboratories in Dallas, he was watching history repeat itself.

The Magnolia scientists (Magnolia is Socony-Vacuum's affiliate in the Southwest) have been making a long-term study of recent sediments — "recent" being 20,000 years or so to a geologist. By studying the way these sediments behave, they hope to learn more about how oil-bearing sediments acted in ancient times.

Before skin-diving became a popular sport, the geologists collected samples from the Gulf of Mexico by dredging from a boat. But now they have borrowed the aqualungs, goggles, and flippers of the skin-diver — and are taking a close look at the bottom of the sea.

Leader of the underwater team is Dr. Dan E. Feray, head of the geological group at the Field Research Laboratories. All the team members are experienced swimmers. But before venturing into deep water, they learned the techniques of skin-diving in a Dallas swimming pool. Then they practiced diving in the San Marcos River. When they were good enough at flipper-flapping to pass the diving test the U.S. Navy gives to its frogmen, they went down to Galveston, chartered a shrimp boat, and put out to sea.

They headed for an area about forty-five miles south of Galveston. For two weeks, they explored the floor of the Gulf of Mexico, shifting their location every day so they could study sand, coral, and mud bottoms. To spend as many daylight hours as pos-

Much of the material on these pages was drawn from an article in

sible on the scene, they left Galveston before dawn every morning and didn't put in to shore again until after dark at night. They worked in depths of from twenty to sixty-five feet. In the deeper places they found the work so exhausting that each geologist could spend no more than half an hour a day on the bottom.

It was quiet on the ocean floor, except for Dr. Nelson's skittish clams. Once, however, the underwater quiet was broken by a series of dynamite explosions. Another oil company was making a marine seismic survey a dozen miles away. The scientists on the boat couldn't hear the explosions, but the noise was loud and clear underwater. "First time I heard the sound," says Richard A. Mills, "I thought someone was knocking on my air tank with a metal tool, trying to give me a signal — but there wasn't anybody near me."

One species of fish, like the clams, took a dim view of the flipper-footed intruders and nose-dived into the sand at the geologists' approach. But most of the fish were friendly. Red snapper, angelfish, sheepshead, triggerfish, and many other beautifully colored tropical fish swam up and nudged the divers' face masks.

Two of the geologists — Dan Feray and William A. Jenkins — are nearsighted. But they discovered that the water corrected their vision.

Geology technicians Alvin B. Craig and Rex H. White Jr. carried gunnysacks to the bottom and filled them with starfish, snails, shellfish, and other plant and animal life. They used dandelion diggers and geologic picks to pry some of the specimens from the coral.

The specimens collected in the gunnysacks, together with samples of silt, sand, and marine life that were scooped up in a dredge, were carefully sorted and packed in steel cans. Each can was labeled by location for later analysis at the Dallas lab. The geologists used a coring barrel to collect samples from *under* the ocean floor. The coring barrel — an eight-foot steel pipe weighted on top — was lowered over the side of the boat and plunged into the bottom. Then they hauled it up and pulled out the cores for future study.

The skin-divers took films of the undersea world with movie cameras rigged in watertight plastic cases. Scenes from the film were shown in newsreels at more than twelve thousand movie theaters, and on television.

The skin-diving geologists have already made two expeditions into the Gulf of Mexico on their "recent sediments" study. With the mass of information and sea-bottom samples they took back to the Dallas labs, they hope to get better acquainted with an old friend that geologists call a "stratigraphic trap."

An old friend, but an elusive one. In 1953, Socony-Vacuum drillers, operating in the Pembina area of western Canada, expected to reach oil at 6,000 feet in a structural trap. But at 3,500 feet their drill bits found oil in a stratigraphic trap. The discovery was the biggest in North America in several years — the Pembina field. Some twenty years earlier, Texas oil men drilled into another stratigraphic trap — and opened the great East Texas field. Between the East Texas and Pembina discoveries, many other stratigraphic traps have been found — many of them by accident.

Dan Feray explains that stratigraphic traps are sand bars and limestone reefs of ancient seas. Ages ago, they were covered by mud and silt that hardened into a non-porous rock. This rock prevented the oil formed in the sand and limestone from seeping out.

Most of the world's oil fields have been found in places where huge upslanted or arched rock formations have trapped the oil. These *structural* traps give fairly clear answers to the queries of the geophysicist's instruments. But *stratigraphic* traps are formed in undisturbed layers that baffle the instruments. You can't tell where they are unless you drill.

But Dr. Feray's geologists hope they can eventually come up with some clues that will help locate oil-bearing stratigraphic traps. The clues will come from the answers to questions like these: Why do certain marine animals live only in mud? Why do others live only in sand, and still others only in shell debris? Why is the bottom of the sea composed of coral in one place, mud in another place, and sand at only a short distance away?

Some of the answers may already be in the notebooks of the geologists at the Field Research Laboratories. They're not saying. But the day may come when a driller will strike oil in Oklahoma, or off the shores of Texas, or in some remote corner of the world — thanks, in part, to a team of geologists who went skin-diving in the Gulf of Mexico.

The whole world is the laboratory of the geologist. Generally speaking, his quest is the study of the earth and its materials. His scientific searchings may take him to jungles, deserts, mountains, or — as in the case of skin-diving geologists — to the depths of the sea. So if you have an ability in science plus a love of travel and the outdoors, geology may be the career for you.

Geology is subdivided into many fields. Highly trained specialists are required in all of them. Whatever his field, the geologist must have a broad scientific background. If you select geology as your major in college, you'll need to take other science courses — especially physics, chemistry, mathematics, and biology.

As for graduate work, it isn't necessary. But, in general, more education will lead to a better job and higher pay. Nearly half of all professional geologists have either a master's or a doctor's degree. Scholarships, fellowships, and part-time assistantships are usually available to worthy students to help them finance graduate study.

When you finish your education, chances are a job will be looking for you. The need for geologists is growing. Many companies are sending representatives to colleges and universities to seek out young people for employment. The Federal Government, colleges and universities, and museums also need geological scientists.

For more information on geology as a career, write the American Geological Institute, 2101 Constitution Avenue, N.W., Washington 25, D.C.

BONE-TIRED after exploring sea bottom, geologist climbs aboard shrimp boat.

The Flying Red Horse, *courtesy of Socony-Vacuum Oil Co., Inc.*

Stranger than fiction

The case of the silent howlers

When the monkeys fell silent, this was the first clue that anything was wrong. Investigation showed the cause: yellow fever was moving northward. Part 1

By Murray Morgan

One of the most characteristic sounds of the Central American jungle is the strident cry of the howler monkeys. In 1948, people living at the edge of the jungle in southern Panama were made uneasy by a strange silence: the monkeys had stopped yowling.

Hunters, venturing into the quiet forest, failed to see any howlers in the trees. But they did bring out the remains of a few monkeys that had been found dead on the jungle floor. Then it was not just the Panamanians who knew a touch of fear. Apprehension was felt as far away as Washington and Geneva. For when jungle monkeys die in large enough numbers for some of the carcasses to escape the scavengers, something is very wrong. It usually means that yellow fever, one of the six great pestilential killers of mankind, is on the march.

In November, 1948, a young man was brought into the Santo Tomás Hospital in Panama City suffering from a disease marked by high fever. He had lived near the village of Pacora, in the jungle, eighteen miles east of Panama City. He died five days after coming down with the fever, and his symptoms included headaches and black vomit.

These symptoms indicated the possibility of yellow fever — but the disease had been driven from Panama more than forty years before. Still, this looked like yellow fever. The pathologist at the hospital took a specimen of the dead youth's liver to see if it had the lesions characteristic of the disease. The liver did not look much like those he had seen illustrated in the textbooks, so he diagnosed the illness as a form of acute yellow atrophy.

A few days later a second man was brought in from Pacora with a high fever. He too died. And so did a third. Since their symptoms were much like those of the first man, the pathologist took no liver tissue for examination. A fourth death early in December caused him to examine a liver specimen, and he saved some of the tissue for further study. However, he again diagnosed the case as acute yellow atrophy.

Late in December the pathologist was confronted with a fifth autopsy, still another man from Pacora. Again it looked like acute yellow atrophy to the pathologist, but he wanted outside assurance. In mid-January Colonel Norman W. Elton of the United States Army Medical Corps in the Canal Zone was asked to visit the hospital and look at the slides.

He went to Santo Tomás that afternoon, taking along a slide of a typical yellow-fever liver, which he had acquired some years before. The pathologist was out, so the colonel left the slide on his bench. The next morning Colonel Elton returned to the hospital. The pathologist had a slide in a microscope and asked the colonel if he thought it was yellow fever. "It was," Elton said later, "about the same as being asked to identify the full moon in a starlit sky."

Samples of the liver tissues taken from the first, fourth, and fifth cases were flown at once to the Army Medical Research and Graduate School in Washington, D.C., and to the Rockefeller Laboratory in Rio de Janeiro. Both laboratories sent back reports that all three of the specimens were positive for yellow fever.

Field investigators went to Pacora to learn the backgrounds of the cases. That of a man we shall call Tomás Rosales was typical. He lived and worked on a farm a mile east of the Cabra River. The farm consisted of a clearing in the first-growth jungle. He had been working in the rice field near the forest margin when he became ill. After three days of illness he was admitted to the hospital, where he died two days later.

The investigators learned that several other persons in the community had suffered from a similar disease during the period when the five men died. Furthermore, bands of howler monkeys, which may carry the yellow-fever virus in their bloodstreams, had been seen near the village at the time of the outbreak but had since disappeared.

There could no longer be doubt that this was yellow fever. The entire Republic and the Canal Zone were threatened. An emergency conference was held January 15, 1949, at the Board of Health laboratory in Panama City. Present were all the public health officials of the Canal Zone, the armed forces, and the Republic of Panama, as well as two international advisors from the Pan-American Sanitary Bureau, Regional Office of the World Health Organization. They agreed upon a united program. Measures included immediate studies to determine in what areas the yellow-fever virus was active and the direction in which it was spreading, widespread spraying against the mosquitoes that transmit the disease in urban areas, and the immunization of as much of the population as possible.

During the countrywide vaccination campaign, which lasted six months, four out of five Panamanians were treated. The teams used every possible form of transportation, including air-

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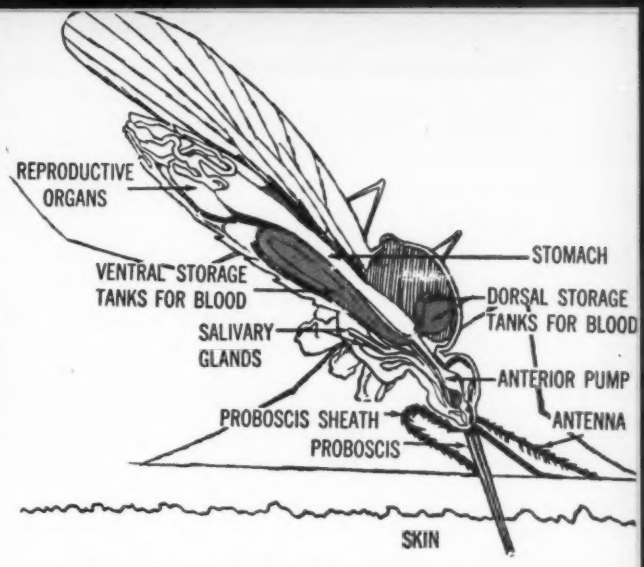
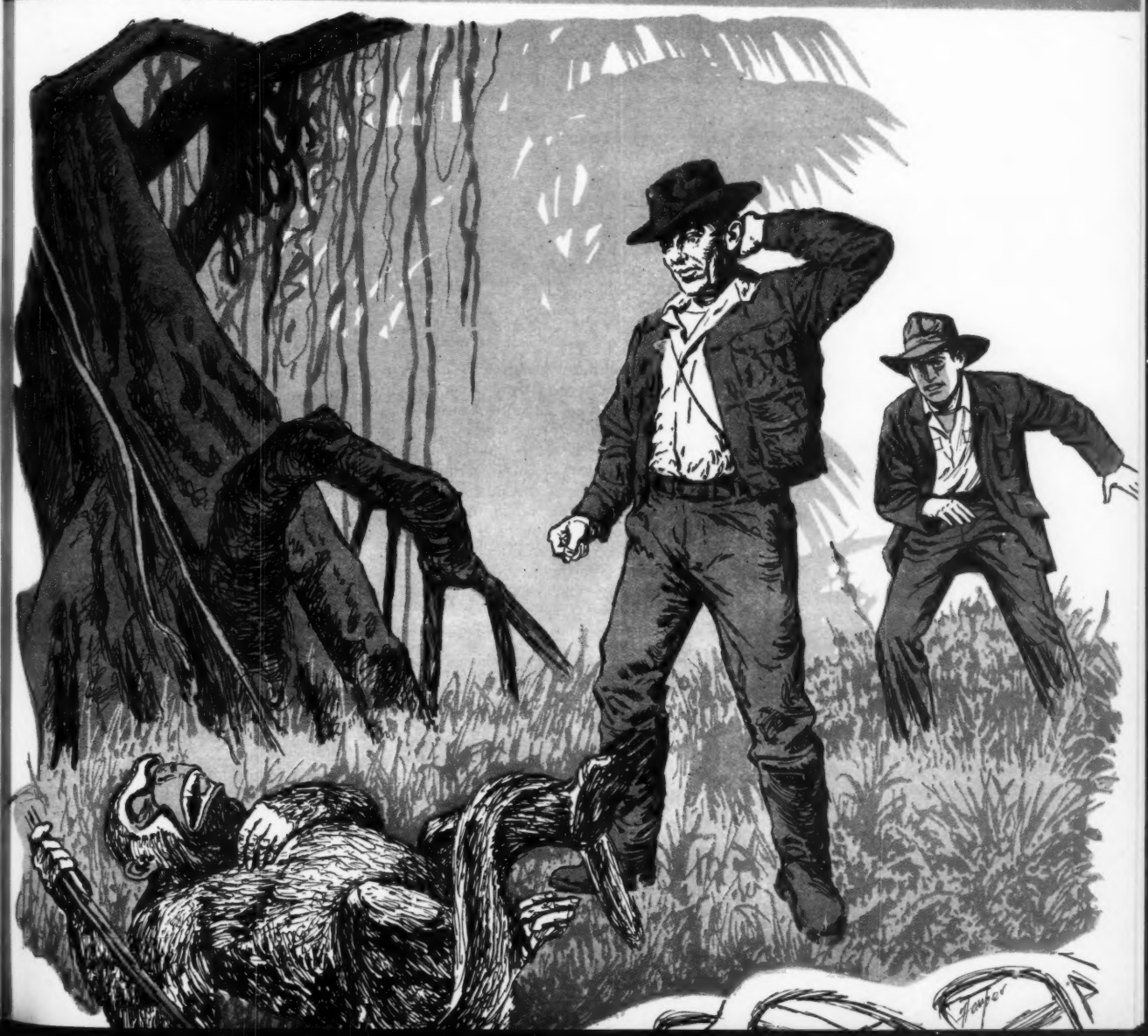
HOWLER MONKEY of Central American jungle. Hunters were puzzled (*below*) when they found dead howlers.



CROSS-SECTION of yellow-fever-carrying mosquito shows how insect uses proboscis to suck in blood.



plane, helicopter, motorboat, dugout, horse, and foot travel. In order to reach the Guaymi Indians, approximately three thousand in number, on the northern slopes of the mountains of the province of Bocas del Toro, it was necessary for the medical team to make a twelve-hour sea voyage in a tugboat to the mouth of the Cricamola, then to go three hours by motor launch up the river, transfer to a dugout for four hours, switch to horses for two more hours, and finally walk for the last two hours.

Mosquito inspectors found breeding places of yellow-fever-carrying mosquitoes in 31 towns and villages. These, and 162 other urban areas, were treated with DDT residual spray. Blood samples were taken from men who lived near or worked in the jungles. Monkey blood was collected from ten control areas to determine what was happening in the jungles. Twenty-six emergency medical posts were set up to obtain liver specimens from persons who had died from undiagnosed fevers of ten days' or less duration.

This was one of the most comprehensive emergency campaigns in medical history. It kept yellow fever from leaving the jungle and devastating the cities of Panama as it so often had done during the 1800's. It probably saved thousands of lives. But it did not halt the advance of yellow fever through the jungles toward North America.

Yellow fever swept north and west, moving through the monkey population and occasionally touching human beings who ventured into the forest. By August it was approaching the Panama Canal. Would it cross? Experts had some hope that it would not. The zone, in the distant past, had proved a breaking point for waves of fever sweeping up from Colombia.

If the disease did cross the canal, however, the experts feared that it would probably follow the jungles west and north through Costa Rica, Nicaragua, Honduras and Guatemala into Mexico. It might burn itself out somewhere along the line, or it might surge as far as San Luis Potosí, in Mexico, where the jungle runs out of monkeys. Nor was it considered impossible that the wave would reach the United States. The Surgeon General of the United States has declared the entire southern third of the nation to be a receptive area for yellow fever. One person coming into these states after having been bitten by an infectious mosquito could touch off an epidemic.

In January of 1950, a farmer died of yellow fever in the Chagres District of Panama. This was on the Atlantic side of the peninsula, west of the canal. The moat had been crossed. The route north lay open.

The history of yellow fever

Yellow fever is a tropic disease that occurs primarily along the shores of the Atlantic Ocean. It was first diagnosed in the Americas, but it may well have originated in Africa and reached this continent with, or soon after, Columbus.

In the United States, yellow fever remained one of the great plagues until fifty years ago. In 1878, it killed thirteen thousand people in the Mississippi Valley alone. Philadelphia had twenty epidemics of yellow fever; New York, fifteen; and Boston, eight. At least a thousand people died in an epidemic in the South in 1905.

Yellow fever's greatest impact on the United States, however, stemmed from two epidemics that occurred outside the country: one decimated American troops sent to Cuba during the Spanish-American War; the other turned the French attempt to dig the Panama Canal into a disaster.

As the result of casualties among American soldiers in Cuba, an Army commission under Major Walter Reed was sent there. The results are a famous story: with human guinea pigs, Major Reed demonstrated the truth of a theory first put forward by a Cuban doctor, Carlos Juan Finlay, in 1881. Finlay believed that the *Aedes aegypti* mosquito transmitted yellow fever.

From the truth of Finlay's theory a second truth seemed to flow: get rid of *Aedes aegypti*, and you would get rid of the disease. Fortunately, *aegypti* was one of the easiest mosquitoes to exterminate. It breeds in pools of quiet, warm water, usually man-made pools within a short flight of human habitation.

So William Crawford Gorgas came to Havana with orders from the United States Government to dry up these pools. He drained the swamps closest to the city, and he ordered the people of Havana to get rid of all casual collections of water near their homes and to screen the water that had to be kept for domestic use. With no place to lay their eggs, the mosquitoes disappeared. With them went yellow fever.

Yours for the asking

Physics as a Career, published by the American Institute of Physics, gives specific pointers on academic preparation and scholarship opportunities. It describes employment possibilities, naming Government agencies that employ physicists. Check No. 11111.

Should You Be an Atomic Scientist? explains how science "specialists" — mathematicians, chemists, metallurgists, etc. — fill vital needs in this vast new field. The pamphlet, one of the New York Life Insurance Company's careers series, discusses seven characteristics that future atomic scientists should have. Check No. 11112.

Union Carbide Corporation's 32-page booklet, *Mesa Miracle*, presents a broad picture of uranium production on the Colorado Plateau. Illustrations show scientists pin-pointing deposits, extracting the mineral from the ore, and processing uranium. Check No. 11113.

A comprehensive booklet, *Careers in the Mineral Industries*, explains in detail the types of jobs available to geologists and geophysicists, mining engineers, petroleum and gas engineers, metallurgists, and ceramics engineers. Each job classification covers: the scope of the position, the "first job," living conditions, the future. Also listed: accredited undergraduate institutions offering degrees in mineral engineering. Check No. 11114.

Check your choice, clip coupon, and mail to: **Yours for the Asking, Science World, 575 Madison Avenue, New York 22, N. Y.**

- ☐ 11111 Physics as a Career
- ☐ 11112 Should You Be an Atomic Scientist?
- ☐ 11113 Mesa Miracle
- ☐ 11114 Careers in the Mineral Industries

See also: page 2

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PLEASE PRINT

A few years later, General Gorgas repeated the experiment on a grand scale in Panama, making possible the canal. It all seemed so simple. End the mosquito, end the disease.

One question, though, still bothered the researchers of the Army's Yellow Fever Commission. The *Aedes aegypti* transmitted the fever, without doubt, but how? What was it that passed from man to mosquito to man, carrying yellow fever? Researchers spent weary days trying to grow a culture of yellow-fever germs. Month after month, laboratory technicians stared into microscopes, looking in vain for the nameless something that carried the disease.

It was James Carroll, the first man to submit to the bite of an infected *Aedes aegypti* in Walter Reed's experiments, who discovered part of the answer. He demonstrated that the disease must be carried by something too small to be found under the microscopes of the day — a virus.

Finding that the agent was invisible still did not answer the question of how the mosquito passes the disease from man to man. The Yellow Fever Commission continued its research. It learned a number of interesting things. Probably the most important was that if a mosquito takes blood from a yellow-fever patient and immediately bites someone else, the person bitten does not get the disease. From ten to twelve days must pass before the mosquito can transmit yellow fever. Scientists still do not know what happens inside the mosquito during this period. It is believed that the virus goes into the mosquito's stomach with the human blood, passes through the stomach wall and gets into the blood of the mosquito, and so reaches the salivary glands, from where it can be injected into the next victim.

While all this was being learned, slowly and painfully across the years, the war to exterminate the *Aedes aegypti* continued. It was led by the Pan-American Sanitary Bureau and the Rockefeller Foundation. Country after country was cleared of *aegypti*. By 1925, Central America appeared to be wholly clear, and the only focus left in the Western Hemisphere was believed to be in Brazil.

Hopes for victory were raised still further when Dr. A. F. Mahaffy, one of a team of Rockefeller doctors studying yellow fever around Accra on the Gold Coast, made a major breakthrough in the summer of 1927. Dr. Mahaffy took blood from a 28-year-old African named Asibi, who had a mild touch of fever. Dr. Mahaffy inoculated four laboratory animals with some of Asibi's blood — two guinea pigs, a Marmoset, and a rhesus monkey that had just arrived from India. On the Fourth of July, the monkey came down with yellow fever. For the first time, the virus of the disease had been transmitted experimentally to an animal other than man.

Having lab animals that would serve as hosts to the disease opened the way to new lines of research. The Asibi strain of the virus was kept going from monkey to monkey. In time the virologists were growing yellow-fever virus in white mice; in small pieces of living tissue, which were themselves growing in a nutritive broth; in chicken embryos; in mice embryos. Viruses, as they grow in different environments, tend to change. The Rockefeller team set out to develop a virus from which much of the virulence would be gone. After numerous failures, they succeeded in passing some of the Asibi strain through more than two hundred cultures made from the embryos of mice. The virus became attenuated — that is, it lost the power to bring on a severe attack of yellow fever, but retained the power to stimulate the growth in the human body of antibodies against yellow fever. From the blood of one West African a vaccine was developed that now protects millions of human beings exposed to yellow fever.

During this same period, the researchers also developed a way of determining whether a person had ever been exposed to yellow fever and thus acquired a natural immunity. This method is used with samples of the blood of children born since the time when the disease is thought to have disappeared. If antibodies are found, yellow fever is still around.

Such, then, was the stage reached in 1932. Yellow fever was theoretically on the edge of extinction, at least in the Americas. It was isolated in Brazil and neighboring countries, and medical teams were preparing a final assault with the new weapons at their disposal.

Then there occurred an outbreak in Vale de Canaan, in the state of Espirito Santo, Brazil. This was odd, since Vale de Canaan was a rural area and yellow fever was thought of primarily as a town and house disease, one that people contracted through being bitten by *Aedes aegypti* that had been born within a hundred yards of their houses. When members of the Brazilian National Yellow Fever Service, led by Dr. Fred L. Soper, reached the area, they found something much more startling.

There was yellow fever in Vale de Canaan, without doubt. But there were no *aegypti* — not one. Something else was passing the disease from man to man.

[*To be continued Nov.* 25]

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(Advertisement)

On the light side

Brain teasers

The stopped clock

Your only clock has stopped, and you have no way of knowing the correct time. You wind the clock. Then, leaving it, you walk to a friend's house. You note the time you arrive. After visiting for an hour or so, you note the time again, then walk home. You have no idea how long it takes you to walk the distance to and from your friend's house. Can you set your clock correctly when you get home?

The painted cubes

You decide to paint some sugar cubes, painting each face of each cube either red or blue. How many cubes can you paint that are different from each other?

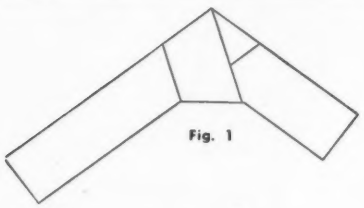


Fig. 1

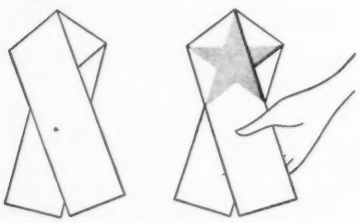


Fig. 2 Fig. 3

Fold a pentagram

The regular pentagram is a five-pointed star formed by extending the sides of a regular pentagon. It is not easy to draw with a ruler and compass. This fact makes the following construction all the more surprising.

First tie an ordinary overhand knot in a uniformly-wide strip of paper, pulling the knot tight and pressing it flat (Fig. 1). A translucent paper such as typewriter bond should be used. Fold one end of the strip over the knot (Fig. 2). Then hold the knot up to a window so the light shines through (Fig. 3). You will see the shadow of a perfect pentagram.

The pentagram was one of the most popular of medieval mystic symbols. It was used chiefly as a charm to ward off the "evil eye" of witches.

No time for school

"But I don't have *time* to go to school," explained Joe to the truant officer. "I sleep eight hours a day, which adds up to 122 days a year. There's no school on Saturdays or Sundays, which amounts to 104 days a year, and we have 60 days of summer vacation. I need three hours a day for meals (45 days a year) and at least two hours a day for recreation and relaxation (30 days)."

Joe jotted down these figures as he spoke. Then he added up all the days. They came to exactly 361.

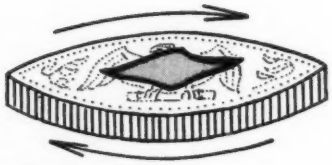
"You see," said Joe, "that leaves me only four days to be sick in bed, and I haven't even considered the seven school holidays we get every year."

The truant officer, though, was not taken in. Were you? What is wrong with Joe's figures? (See Answers.)

Galileo vs. Aristotle

Everyone knows about Galileo's famous experiment of dropping unequal weights from the leaning tower of Pisa. The experiment proved that Aristotle was mistaken in his belief that heavy objects fall faster than lighter ones.

You can repeat this historic experiment on a small scale by dropping a half-dollar and a tiny piece of paper. To eliminate air resistance on the paper, put it on top of the coin as shown. Drop the coin to the floor, giving it a slight spin to keep it horizontal while it falls. The coin and paper will fall together.



Drawings by LoCurcio

But, you may object, perhaps currents of air flowing around the falling coin cause the paper to stick to it. To prove this isn't so, hold the coin and paper high in the air. Then, instead of dropping the coin, carry it down at a speed faster than normal falling speed. The piece of paper will be left behind. — GEORGE GROTH

Answers

THE STOPPED CLOCK: You can. From the time elapsed on your clock during your absence, subtract the length of time you were at your friend's house. This gives the total time you spent in walking. Half of this is the time it took you to walk back. Add this to the time you left your friend's house. You now have the correct time to set your clock when you get home.

THE PAINTED CUBES: You can paint one cube all red, one all blue, one with one red face, one with blue face, two with two red faces, two with two blue faces, and two with three red and three blue faces. Total: ten different cubes.

NO TIME FOR SCHOOL: Joe in several cases accounted for the same time twice. During his vacation, for example, he both ate and slept, yet he accounted for this time separately.

Announcing the United States Army's Graduate Specialist Program 1958~1959

The Purpose: This program is offered to provide qualified high school graduates with the technical schooling which will enable them to join the Army's key group of specialists, its select team of experts in every field from electronics to rocketry and guided missiles.

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The Qualifications: To qualify as a Graduate Specialist, you must pass certain qualification and aptitude tests and be a high school graduate. However, you may apply while you are still in your senior year and, if qualified, enter the program after graduation. It is advisable to apply early, since quotas for each course are limited and qualified applicants are selected on a first-come-first-served basis.

The Procedure: To apply for the Graduate Specialist Program, visit your local Army Recruiting Station. Your Army Recruiter will give you an enlistment screening test. After passing this initial qualification test, you will be interviewed by the Recruiter who is an experienced counselor. He will discuss your academic background and interests with you. Based on your own abilities and desires, he will help you select a first choice course and two alternates. If quotas for your first choice course are filled, you may still become a Graduate Specialist in one of your selected alternates. Your Army Recruiter will then forward your application for processing. You will later receive a formal letter notifying you that a place in a course of your choice is waiting for you. Not until after high school graduation and shortly before your course begins will you actually enlist, and then only for three years. Before enlistment, you will take two final tests, the Armed Forces Qualification Test and the Army Qualification Battery. After making qualifying scores in these tests relating to your particular chosen field, you are ready to enlist as an Army Graduate Specialist.

The Benefits: Through this unique program, today's Army offers qualified high school graduates an outstanding educational opportunity—a tremendous headstart toward a successful specialist's career—as well as the chance to join the Army's select group of key personnel.

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- Neuropsychiatric Procedures
- Dental Laboratory
- Medical Laboratory Procedures
- Photographic Laboratory Operation

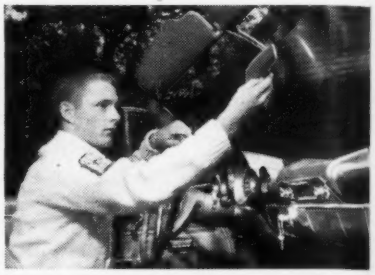
"Dad gave me the car

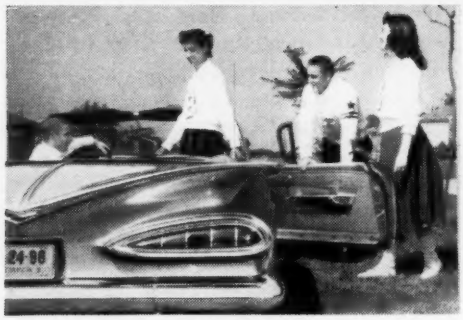
to drive to the Big Game"

"TODAY'S THE BIG GAME and Dad's letting me take the car and the gang. He knows we'll get there—*and back*—safely 'cause we get our thrills at the game, not on the road. That's why he lets me take the car on big dates."

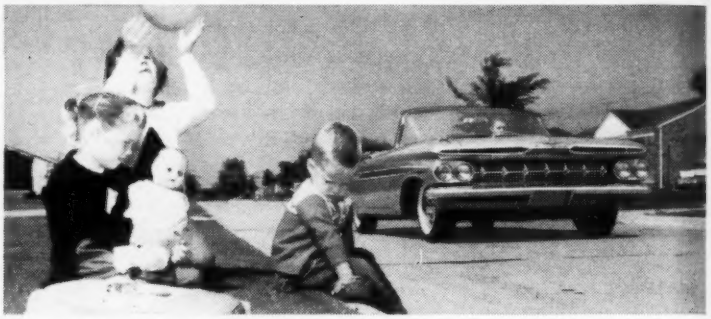
"LOOKING OUT BEFORE PULLING OUT is a good way to avoid accidents. It takes a second—and can save a life."

"MAKING SURE THE MIRROR'S RIGHT helps me make sure I can *see* what's behind me before I pull over or make a turn."





"PULL CLOSE TO THE CURB when you pick up passengers and you'll never block traffic. It's easier to get into the car, too."



"KIDS ARE A CAUTION—particularly when they're playing near the street. I always slow down—you never know when a little boy or girl will chase a ball out into the street."

"WE'RE HERE FOR THE KICKOFF in plenty of time because we gave ourselves plenty of time to get here. And after the game, I'll drive safely to the victory party, too. Dad knows I drive that way, that's why I get the car."

General Motors

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TEACHERS:
Reprints are available upon request for bulletin boards, classroom use, etc. Write General Motors, Public Relations Staff, Detroit 2, Michigan

How to do it

Homemade Geiger counter

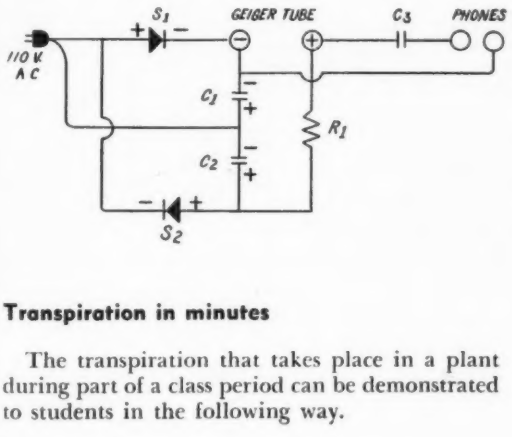
A simple and inexpensive Geiger counter can be made by following the wiring diagram below. With it, individual laboratory work with radioactive materials can be done in class.

The counter circuit is actually much simpler than the usual radio circuit. It is made with standard and easily obtainable radio parts and can be built on a breadboard in a matter of minutes. The unit operates from a 110-volt A.C. line. Its circuit uses a voltage doubler, which provides just over 300 volts to a low-voltage Geiger tube. Be sure that you get a 300-volt Geiger tube. They are available only from: Electronic Products, Inc., 111 E. 3rd St., Mount Vernon, N.Y.

In addition to the Geiger tube and headphones, the following parts are needed: two 100-Ma. dry rectifiers (S_1 and S_2 in diagram), two 16 mfd., 150 WV electrolytic condensers (C_1 and C_2), a .002 mfd. bypass condenser (C_3), a 1.5 megohm, ¼-watt resistor (R_1), and circuit wire.

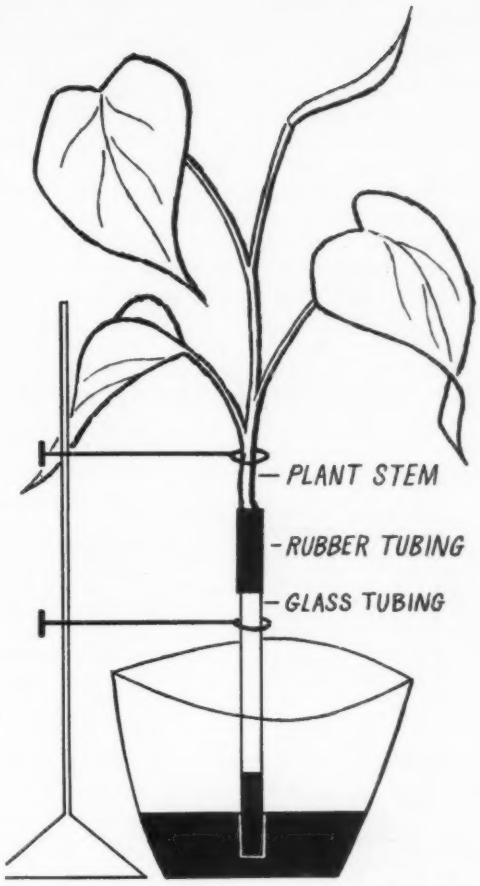
When the assembly is completed on a wooden board, make sure no bare wires extend from the board. Then cover the assembly with plastic or metal, or place the unit in a large tin can, to prevent shocks. Do not touch parts of the circuit with the bare hands.

This instrument can detect cosmic rays, background radiation, and the usual beta and gamma rays from radioactive materials. To detect only gamma rays, hold a sheet of aluminum between the radioactive source and the Geiger tube. To detect only cosmic rays, cover the tube with a sheet of lead. It would be wise to mount the Geiger tube inside a protective tube made of strong plastic or of metal that has holes drilled in it to allow radiations to enter.



Transpiration in minutes

The transpiration that takes place in a plant during part of a class period can be demonstrated to students in the following way.



— Drawings by LoCurcio

Materials needed:

1. A ½- to 1-inch length of rubber tubing of a suitable diameter (see below).
2. A 4-inch length of glass tubing that fits tightly into the rubber tubing.
3. A suitable container of water for performing the operations (see below).
4. A bowl or a beaker containing mercury.
5. A ringstand-support for holding the demonstrated plant in position (see drawing).
6. A healthy broad-leafed plant.

Method:

1. Immerse the piece of rubber tubing and the piece of glass tubing in the bowl of water.
2. From any leafy plant, such as ivy, cut a sprig several inches long. Then perform the following operations *under the water.*

(a) Cut off the stem diagonally about an inch or two from the leaves.

(b) Slide the rubber tubing over the cut end of the stem to make a tight fit.

(c) Insert the glass tubing into the open end of the rubber tubing.

(d) Holding your finger over the open end of the glass tubing to prevent air from displacing

the water in the glass tubing, remove the plant and the attached tubing. Immerse the lower end of the glass tubing (keeping your finger in place) under the mercury in the mercury bowl.

(c) Remove your finger, and fix the supports as shown in the drawing.

Within a few minutes, the transpiration of water through the leaves will cause the plant to suck up the water in the glass tube. The mercury level within the tube will then rise to take the water's place.

Set up a control in exactly the same way, but remove the leaves from the plant.

This demonstration can lead to a number of other experiments. For example, how is transpiration affected by the size, number, shape, or thickness of leaves or by the position of the leaves on the stem?

For your bulletin board

THIS IS BOSWELL PONTOON, Jr. when he first started high school
HIS PARENTS · · ·
BOSWELL PONTOON, SR. & MRS. BOSWELL PONTOON, SR.
TOLD HIM TO BE A GOOD BOY AND STUDY HARD-AND THEN HE COULD GO TO COLLEGE AND BE A LAWYER OR A DOCTOR OR A THIRD BASEMAN.
AFTER A SHORT TIME AT HIGH SCHOOL, BOSWELL GOT INTO THE SWING OF THINGS AND HIS ACTIVITIES WERE FAIRLY NORMAL · · ·
HE STUDIED SOME · · ·
WENT OUT FOR BASEBALL · · ·
AND OTHER ACTIVITIES · · ·
and AT THE END OF EACH TERM · · ·
BOSWELL BROUGHT HOME HIS REPORT CARD
IF HIS GRADES WERE PRETTY GOOD HIS PARENTS
BOSWELL PONTOON, SR. Mrs. BOSWELL PONTOON, SR.
WOULD PAT HIM ON THE HEAD AND MAYBE BUY HIM A BANANA SPLIT
BUT IF HIS GRADES WERE NOT SO HOT, THEY WOULD SAY "BOSWELL !! HOW ARE YOU GOING TO GET TO GO TO COLLEGE AND BE A LAWYER · OR A DOCTOR OR A THIRD-BASEMAN ?"
THINGS WENT ALONG FAIRLY EVENLY UNTIL ONE DAY IN BOSWELL'S SENIOR YEAR HIS PLEASANT DREAMS WERE RUDELY INTERRUPTED !
COLLEGE ENTRANCE REQUIREMENTS
BOSWELL DISCOVERED THAT ALTHOUGH HIS GRADES WERE PRETTY GOOD HE DIDN'T HAVE THE RIGHT GRADES IN THE RIGHT SUBJECTS TO GET HIS COLLEGE "RECS"
SO · · ·
WHILE THE REST OF HIS CLASS COASTED ALONG HAVING A GOOD TIME DURING SENIOR YEAR · · · ·
· · ·
AND IN THE FALL STARTED OFF TO COLLEGE · ·
POOR BOSWELL
LIBRARY
WAS WORKING HIS BRAIN TO THE BONE, TRYING TO CATCH UP ON HIS COLLEGE "RECS".
MORAL
IF YOU'RE GOING ON A TRIP IT'S A GOOD IDEA (AS ANY FOOL KIN PLAINLY SEE) TO FIND OUT WHAT TRAINS AND ROUTES TO TAKE AND WHAT TICKETS TO GET- BEFOREHAND!

THE CARTOONS ABOVE are taken from a new booklet, 'Going to College,' which was prepared and distributed by the University of California Alumni Association in Berkeley. Its chief point: getting ready for college is a process that should begin years before students head for the campus.

TEACHER'S TOOLS

"CAREERS IN BOTANY," an illustrated two-color poster (11 x 14 inches), will make an excellent classroom bulletin board item. A *free* copy may be obtained by sending a postcard request to: The Chairman, Department of Botany, Duke University, Durham, N.C. *(Note: do not order this through the coupon.)*

W. M. WELCH SCIENTIFIC COMPANY greatly simplifies the teaching of motor-generator theory and application with their new Dissectible Motor-Generator. The well-constructed assembly consists of two Welch No. 2468 Dissectible Motors mounted on one base. Their shafts are coupled together so that one drives the other. The driving unit may be operated on 6 or 8 volts, A.C. or D.C. The generator will deliver up to 1 or 2 volts, D.C., and up to 300 Ma., depending on the circuit used and speed of rotation. Separate connections to the series and shunt coils and to the armature permit the generator to be operated as a self- or separately-excited machine and as series, shunt, or compound wound. Although not recommended by the manufacturer as a source of power, the unit is intended as a thoroughly safe operating apparatus for study and demonstration. *(Check No. 1111A for further information on the Welch Motor-Generator and a complete line of science teaching instruments and apparatus.)*

METALAB-LABCRAFT produces Manifold Science Tables — wood construction — for classrooms requiring multi-science activity. Thoroughly flexible, Labcraft's Manifold Tables have standard, mass-produced base units. This affords savings for schools able to use standard rather than custom-made pieces. For use in high school general science courses, the Manifold-Table units may be ordered with burette rod sockets in the table tops and provisions for water, electricity, and gas services. The W7500 Series may be used as a four-student, two-class table, allowing a separate drawer plus a shared double drawer for each student. Provision is made for plenty of storage space. Extra facilities can always be provided if the unit is desired for more advanced science work. *(Check No. 1111B for further information on the Manifold Science Table and a complete line of wood and metal laboratory furniture.)*

[Please turn page]

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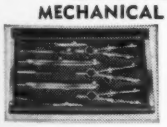

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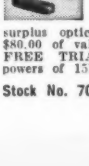

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SAFE-DRIVING TIPS are given in the General Motors advertisement on page 28 in this issue of the student magazine. Titled "DAD GAVE ME THE CAR TO DRIVE TO THE BIG GAME," it was prepared especially for teen-agers. *(If you would like a reprint to post on your school or class bulletin board, check No. 1111C.)*

'Tools' question box

Any questions on teaching tools? Send them to: "Tools" Question Box, Science Teacher's World, 575 Madison Avenue, New York 22, N.Y.

S. W. B., Chicago, Ill.: "Where can I find a good short reference on rocketry for students, including information on hazards and safety measures?"

Answer: See "Amateur Rocketry," by James E. Boggs, *Journal of Chemical Education*, Vol. XXXV, No. 8 (August, 1958), pp. 376-380.

Shop talk

Bio-puns

Robert G. Doty, science instructor at Canby (Ore.) Union High School, seems to hold the title of chief punster among *STW*'s readers. Last spring, he submitted some "definitions" of terminology in chemistry and physics that he uses for review purposes when he thinks his classes deserve a breather. Here he completes his "trilogy" with some puns for biology class:

ALGAE	Good heavens, Lord Tennyson!
AXON	tomahawk atop of
OLFACTORY	aged manufacturing plant
FISSION	angler's activity
KIDNEY	child's leg joint
NUCLEAR	recent and transparent
MUCOUS	sounds from disturbed cat
MUSCLE	to dirty the bottom of a window casing
SETAE	observe golfing apparatus
TRYPSIN	enters, skipping lightly
RESPIRES	concerning towers
GASTRIC	deception with air (or similar material)
MUSHROOM	romantic environment, walled
MOUNTING MEDIUM	swami climbing stairs
CELLSAP	inadequately prepared biology student
LOCOMOTION	crazy gyrations
BIVALVE	purchase liquid-regulating device
CHIPMUNK	anthropoid carpenter
DUODENUM	pair of Levi's
EUSTACHIAN	center for female sheep
GEMMULE	diamond burro
FOREST	in favor of relaxation
HUMERUS	amusing
BERIBERI	chant of treasure-hiding pirates

Students are given the "definitions" and asked to fill in the terms, which are keyed to the number of blanks. Says Mr. Doty: "I find this device particularly useful as a break from the extreme seriousness that attends (and rightfully so) the study of science. The items are just about as ridiculous as they can be and usually provoke some very interesting comments about scientific language."

Twenty-five dollars will be paid for material used in "Shop Talk." The editors regret that they cannot return unused contributions. Send to: Science World Shop Talk, 575 Madison Avenue, New York 22, N.Y.